The FAITHFUL SURVEYOR:

TEACHING

How to *Measure* all manner of Ground exactly, by the Chain onely: *Also*, thereby to take *Distances* of a Mile space, and the Situation of any Building.

SHEWING LIKEWISE

The Making and Use of a New Instrument, called a *Pandoron*; which supplies the use of the *Plain-Table*, *Theodelite*, *Quadrant*, *Quadrat*, *Circumferentor*, and any other Observing Instrument.

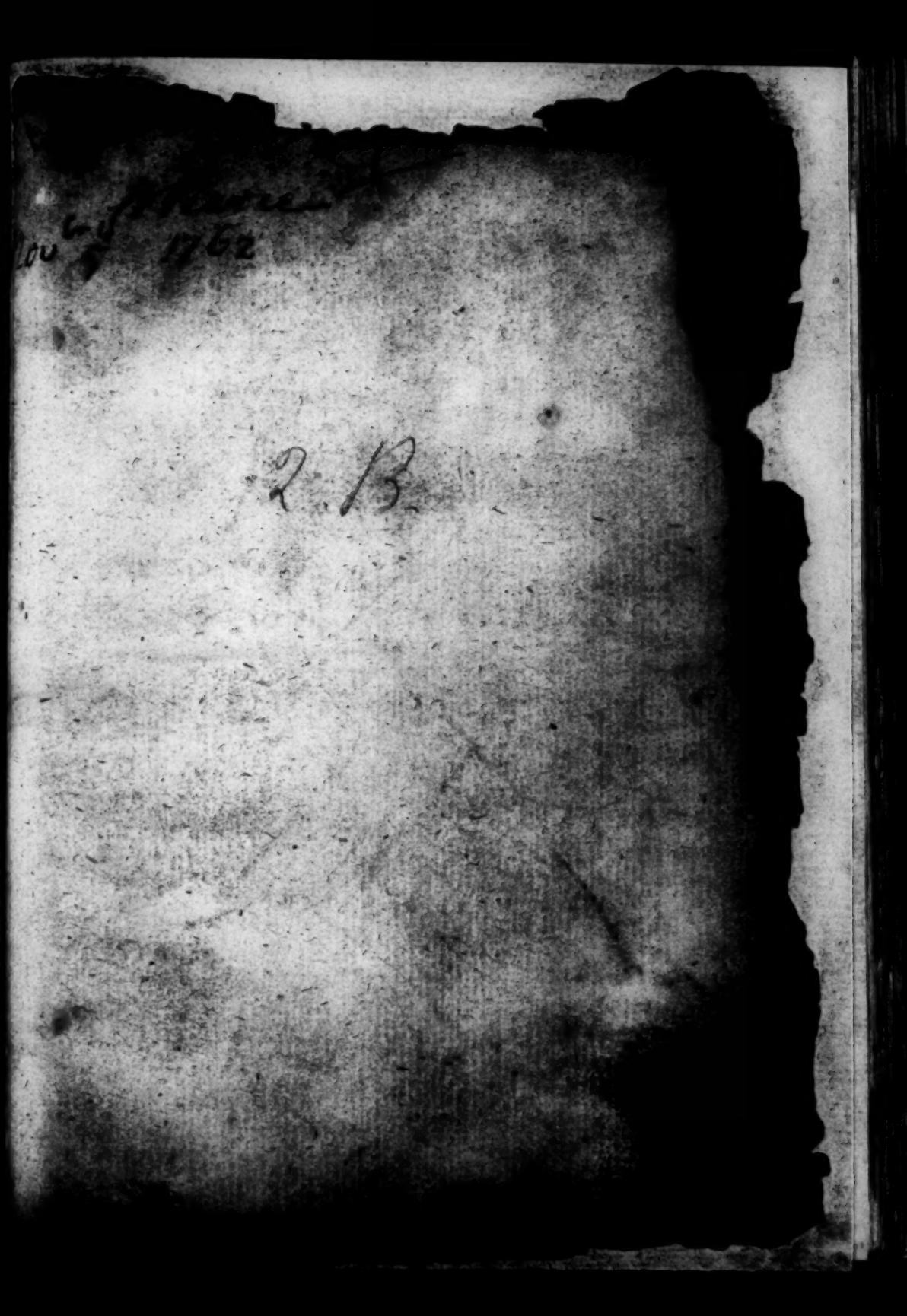
As also divers Secrets for *Conveying* and *Clensing* of *Water*, *Flowing* and *Draining* of *Grounds*, *Quenching Houses on fire*, &c.

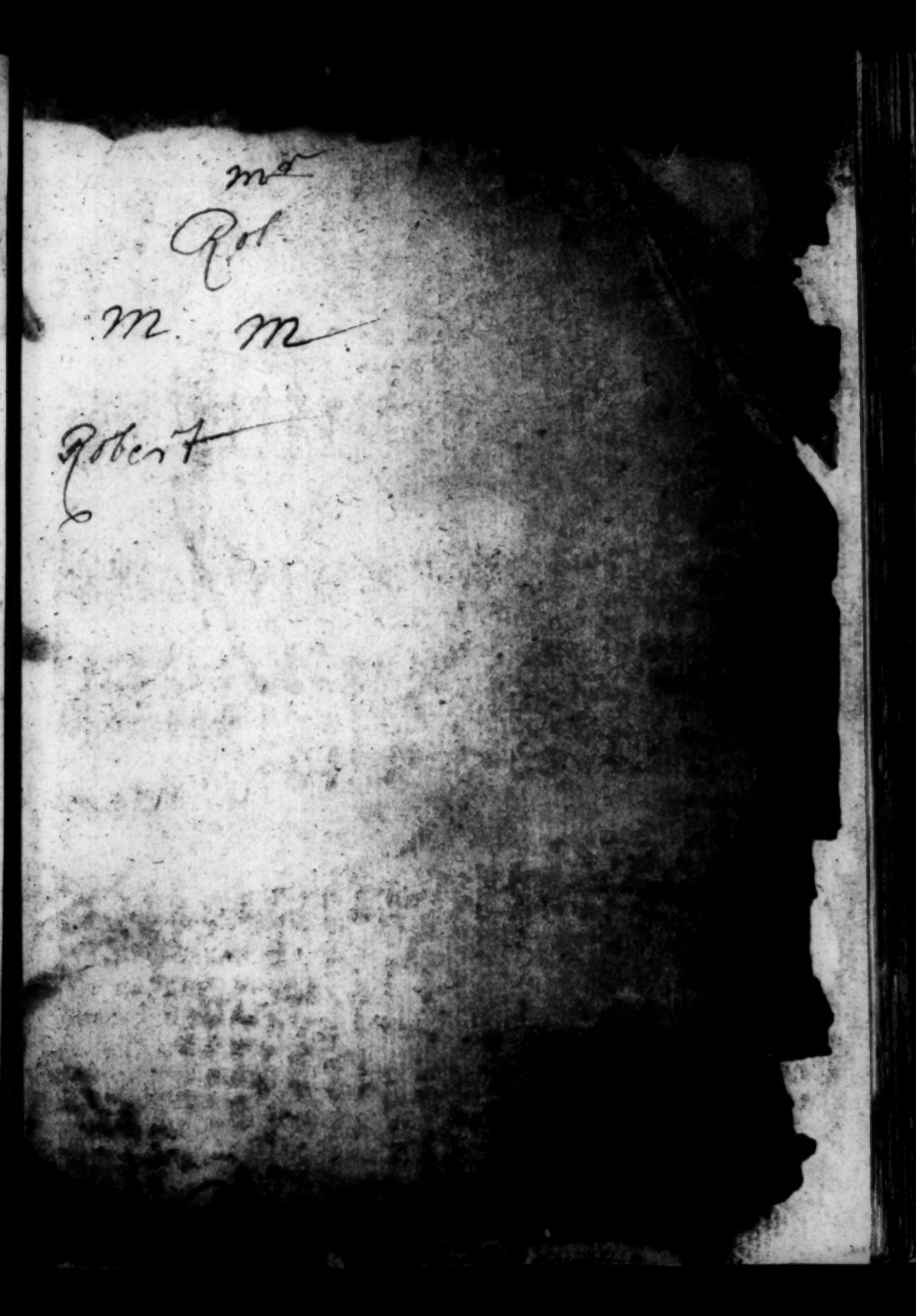
With

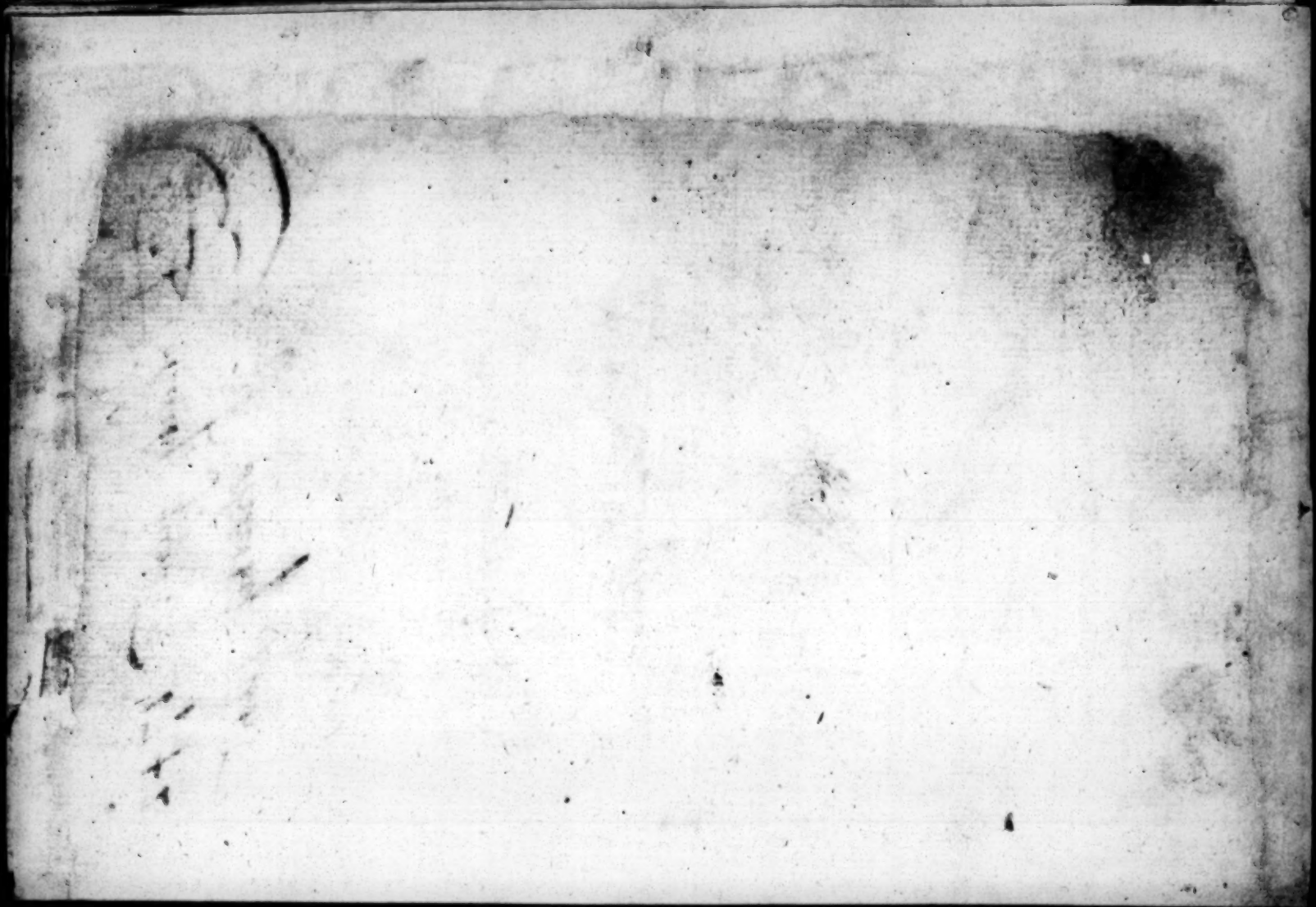
An *Appendix* unfolding Errours in Board and Timber-measure: *With Directions for Making a Carpenters RULE.*

By GEORGE ATWELL late Teacher of the *Mathematicks* in CAMBRIDGE.

LONDON,
Sold by *Ralph Needham* at the *Bell* in *Little Britain*. 1662.







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The FAITHFUL

SURVEYOR:

TEACHING

How to Measure all manner of Ground

exactly by the Chain only:

As the Situation of any Place,

TEACHING ALSO

The Making and Use of a New Instrument,

called a Perpendiculer, which supplies the use of

a Plain-Table, Circumferentor, and

any other Observing Instrument.

Also divers Rules for Casting and Dividing

of Wood, Flooring and Partitioning of Ground,

Squaring Heaps of Stone, &c.

With

An Appendix unfolding Practical Board

and Timber-measure.

COMMISSIONERS OF PATENTS FOR INVENTIONS

By GEORGE ATKINSON late Teacher of the

Mathematicks in CAMBRIDGE.

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LONDON,

Sold by Ralph Newberry at the Bible in Little Britain. 1656.

The Author to the Reader.

PATENT OFFICE LIBRARY.

Courteous Reader,

HAd I fancied the giddy humour of obſcure Wits, who deliver their *dry Notions* as dubiouſly, as the *deceitfull Oracles* did their *Reſponſes* of old; leſt by ſpeaking too plain their ſhallowneſſe be made manifeſt to all men: I might have ſpoke as little ſenſe in as few words to as little purpoſe. But (leaving theſe to their folly) I never accounted their deſign either prudent, or politick; who, having enlarged their ſtock of knowledge by the good Improvement of their opportunities, deliver themſelves ſo darkly to the world, as if they had a mind onely to ſatisfie it what they could do, not what they ſhould. I like *Pythagoras* his counſel, Χρὴ ζυγὸν ἢ χρήσιμα ζυγῷ λέγειν· *Either ſpeak to purpoſe, or hold your tongue*: and, methinks, his counſel pleaſes me better; when I remember the curious *Naturallist's* obſervation, *That men have a double fence to keep in this ſlippery member*; which inſinuates thus much to us, That one had need be wary,

Πολὺ

Hom. Odyſ. γ. v. 230. —Ποῖόν σε ἐπὸς φύγεν ἕρκος ὀδόντων, *What* & *How* he ſpeaks. Now to walk ſecure from the default of each of theſe by-wayes is the driſt of my preſent writing: which, had not the profit of others more ſtirr'd me up to, then the profit, pleaſure, or honour I could have propoſed to my ſelf in ſuch an enterprize, it might have lain buried in oblivion: but I remembred that ſaying of *Tullie; Non nobis, ſed patriæ nati ſumus.* The Law of *humanitie* enjoyns us all with one ſhoulder to help forward any uſefull or profitable deſign, and to treaſure up our *notions* and *obſervations* for the good of others.

Horat. ep. 1. lib. 1. *Condo, & compono, quæ mox depromere poſſum:* *I lay up, that I may lay out*: and we never ſo well diſcharge our ſelves of our *talents*, as when we moſt largely diffuſe them to the improvement of *humane ſocietie*. Seeing then *my* lot is fallen among the *Scriblers* of this preſent age, I make a double requeſt to two ſorts of *Readers*. *Firſt*, to the ingenious Scholar; who may, perhaps, *nauſeate* this *homely fare* and *domeſtick language*, and may, tis not unlike, find *flaws* in the *unvvary connexion*

nexion of the ſenſe, or *unpoliſhed* contents. my *Apology* is onely this, that I write to be underſtood of *all*, and ſo bent my *Countrey-ſtile* to the capacities of thoſe I ſuppoſed would chiefly put the contents of it in practiſe. My *Second* requeſt is to the honeſt countrey-*Farmer*, or whoſoever he be who intends to mete his ground by my Chain: that he would go through with it, & make it his own as he goes: for by ſo doing he may find benefit aſſuredly. My laſt requeſt is to both jointly: not to reject the gronnds of it without good reaſon, nor without a pair of *Spectacles* to convince experience, μητέρα τῶν τεχνῶν, *the mother of Arts*, as the Philoſopher calls her. I might put this into the ballance to weigh down the cenſure of both,

ἄμφω δὲ νεωτέρω ἔστον ἐμεῖο.

But I forbear; leſt I ſhould tire the *Reader's* patience with too tedious a Prologue, letting Truth ſtand on it's own bottom: and commend it in general to the well-improvers of it, and reſt thy friend to ſerve thee,

GEORGE ATWELL.

The Author to his Book.

Go, little Book, and travel through the land:
None will refuse to take thee in their hand.
Fear neither Momus mouth, nor Zoilus quill:
Assuredly, there's none, can do thee ill.
Both simple, gentle, Barons, Lords, and Knights,
Will take thee for their chiefest of delights.
Thou teachest them to measure all their ground;
Which, certainly, will save them many a pound.
Plain-table, and Pandoron with it's sight,
Circumferentor, and Theodelite,
Quadrat, Quadrant, and Chain alone: with these
Thou'lt teach them for to measure with great ease,
Some give a penny to a fire that's past:
But thou giv'st pounds, for to prevent the wast.
Thou cleanest water, flow'st and drain'st their grounds,
And bringest water plenty to their towns;
Thou teachest also to nourish their mold:
And i'th mean while to fill their chests with gold.
Thus doing, thou shalt never be forgotten,
But thou shalt live, when I am dead, and rotten.

G. A.

Upon his worthy Friend, Mr. *George Atwell*, and this his exact *Method* of *Surveying*.

SO, now the Preſs *ha's a new labour paſt,*
Which ſhee'l her beſt acknowledge, if not laſt.
Ne're did her letters *ſuch a poſture ſhow,*
So advantageous, ſince they firſt did know,
T' inſtruct the world how they their Acres *ſhould*
Caſt-up *and* meaſure *by the* perch *or* rood.
'Twas but of late, ſince which applauſe we view'd
Some labours in thi kinde, and thought them good:
But they themſelves will now no more aſpire
To further praiſe; but all conſent t' admire
Content, ſince thou art come. So when we ſpie
A curious piece, that entertains our eye
With livelyneſs, w' approve't; yet, when we part,
Forget it in a livelyer pieces art.
Me thinks, I ſee how with a glance men lay
Others aſide, and by their longer ſtay
Speak their contentment of thy book, and ſtand
Surveying that as thou of late their land;
With ſuch exactneſs. --Here thine art s by thee
So rais'd, that truth *meets with* facility.
Before we did by Sines *and* Tangents *go,*
Theodelete, Circumferentor *too;*
Wayes, that I ſigh to think of: which at th' ſight
Of th' marſhall'd *figures able were t' affright*
An unaſſured eye: who without fear
'Gainſt ſuch a rallied *number dar'd appear?*
Armies *of figures in the field then ſtood,*
Fore-ſight it was (though without fear of blood)
To reach an * herb; *a ſign we could not know*
T' or'ecome that bed, where lately it did grow.

* Herbam porrigere. *Prov.*

* *

This

This by thy chain alone *thou do'ſt; and we*
Admire thine art, admire thy brevity.
Men of thy *temper, and that* owna *mind*
As thine, *ſo ſearching, we may ſeek, not find:*
At thoughts of it we can ſecurely crie;
Th' acuteſt mind ſtill ha's the piercing'ſt eye.

John Hutchinſon, *Trin. Coll.*

To his honoured friend, M^r. *George Atwell,*
on his *Faithfull Surveyour.*

SEe the ſtile alters; Poets did but feign:
*Counter-*Pandora *with her box again.*
Salsbury-ſtones, *that poſ'd the* baker's loaves,
Might here have ſet themſelves in theſe thy groves.
Thy hand hath meted, *and be ſure to try*
There's nothing in't but ſquar'd *by* Geometry.
But ſound thy Art, and teach us how to get
Some lands, as thou haſt taught to meaſure *it:*
For, while we other's mete, *our ſpirits riſe,*
And in their *acres* we *but* Tantalize.
Yet, 'tis too true, eſtates *take no* degree
I'th Conſines of our Univerſity.
He, who was ask'd, Where our poſſeſſions lay,
Might well have thus reſolv'd, In Terr' Incognita,
Or, In the Iſles, *that well may bear the date,*
From their unlucky ſeat, Infortunate.
Help out, invention; and aſſiſt, ye hands:
'Tis Scholars fate, you ſee, to have no lands.
If any they appropriate *will have,*
They muſt, Ben-Syra-*like, mete out their grave:*

Or

Or elſe, if all plots *fail, may try their skill*
To take the angles *of* Parnaſſus *hill:*
But wee'le ſuſpend our judgment, and not dare
To queſtion, till we ſee thy Finis *there.*
The Welſh-*mans ſentence was content to ſtay*
The Apoſtles *leaſure till the* Judgement-day:
And, ſhall not we with patience wait to ſee
The true Effigies *of thy Art and thee.*
Till then wee'le try our skill, no ſpirit raiſe,
Without a Charm, *t'*encircle *thee with* bays.

I. Charles, *T. C. Philomath.*

To the praiſe of the Ingenuous Book of his honoured friend, Mr. *George Atwell*, call'd his *Faithfull Surveyour.*

On the Authors name,

GEORGIUS ATWELL.

Anagram.

AGROS E VULTU LEGI.

THis book's thine own, none need to fear,
Each leaf thy picture *in't doth bear.*
It's the Idea *of thy* mind,
And face *to both are here conjoyn'd.*

On his Book.

I Do not wonder that Meduſa's *head*
At ſight could render living *mortals* dead;
Since the peruſal of this book (whoſe vein
The richeſt gems *of wiſedome doth contein)*
I ſeeing wondred, *wondring* dead *I fell,*
To view ſo much *lockt in ſo ſmall a ſhell.*

On the Author.

WHat ſplendour can, or Jove, *or* Saturn *add*
(Who borrow all) to Sol *moſt richly clad*
In golden *veſtiments? to* Sol, *whoſe rays*
Each morn foretells to all their Halcyon *days?*
Muſe. *T' averre he wants no praiſe.*

WHat glory *then* (dear Muſe, *I prethee, tell*)
To him (whoſe name ſubſcrib'd ſhows all's done well)
Ought we to give? to him, whoſe pregnant wit
Shall live, *while others may in* ſilence *ſit.*
Muſe. *On earth there's none, that's fit.*

ON earth there's none, that's fit? then ſoar the skies,
Brave George! *whoſe fame beyond the clouds doth riſe*
In ſpight of envies Clog, *and does aſpire*
Heavens Canopie *beſet around with fire.*
Thither thy ſelf retire.

D. Ienner. *A. B. Trin. Coll.*

To his much reſpected Friend, Mr *George Atwell*, upon his Book *Of Surveying*, &c.

TO dreſs my lines in praiſe of Thee, my quill
I'de wiſh to dip, where Poets *once did fill*
Their verſing *pens; whoſe thoughts when they'd rehearſe,*
Like metall *in a* mould *would run to verſe:*
I'de ſhew my ſelf then gratefuller *to Thee,*
Then theſe detracting *times could* ſpitefull *bee.*
Here you the Curtain draw, and let us ſee
The now-known worth of conceal'd myſterie.
'Twas Nature form'd the Earth, gave treaſure:
But how to give the price, and meaſure

With

With lines unparalled *th'* embroidred *ground*;
To GEORGE *alone his praiſe it muſt redound:*
'Tis ATWELL *gets the ſtart of Fancies raiſd;*
They at HIS publiſht work may ſtand amaz'd.
Let all the BOOK *now view; give* her *the* praiſe,
That made the tools: *but reach to* him *the* bays,
That is the Artiſt, *and who undertook*
To make himſelf the Author *of this Book,*
To diſſolve Riddles, *make* Ænigmaes *plain,*
Which have requir'd an OEdipus *his brain.*
Envy, *be gone,* Apollo: *be their guide:*
To ſee what Gordian *knots are here unty'de;*
And couched handſomely what might in ſhort
Pleaſe both the Learned *and the* Vulgar *ſort.*

H. Rich, *A. B. Coll. Gon. & Caii.*

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Addenda & Emendanda.

Gentle Reader,

I desire thee to take notice of these my *Additions*, and *Emendations*, before thou readest my Book.

G. A.

Page 9. *l.* 8. *for* first, *read* where. *page* 14 *line* 12. *put out* not. *page* 21. *for* subtendents C X 674, *and* 756. *which are at the top of the third column, set them at the bottom of the first and second columns. p.* 27. *against line* 21, &c. *set in the margin, To bring links into acres and poles. p.* 28. *l* 5 *for* 7. *read* 77. *p.* 36 *l.* 23. *after* quadrant, *read* book or pastboard. *p.* 37. *l.* 2. *read*, tran *viz.* from the line drawn. *p.* 42 *l.* 10. *for* 12, *r.* in. *and line* 15. likewise you may. *and l.* 33 *r.* to the line. *p.* 43. *l.* 11. *r.* a spinny of wood. *p* 45 *l.* 21. *r* save onely if in measuring you have any sorry bound book or past-board: *and against line* 23. *write, How to set out a perpendicular into an angle with the chain onely, p.* 57. *l.* 28. *for* mark *r.* work. *p.* 63. *l.* 19. *r.* the whole angle B. *p.* 64. *l* 10 *r.* A, I finde. *and l.* 13. at D, I finde. *p.* 65. *l.* 7. *for* 10, *r.* 16. *and l.* 11. *&* *l.*, 13, *for* L. *r.* lin. *p.* 69. *l.* 12. *for* edge, *r.* eye. *and l* 29. *r.* 100 of the Quadrate. *p.* 70. *l.* 34, *for* you, *r.* I. *p.* 72. *l.* 9. *for* declination, *r.* the angle of the wall and Sun. *p.* 73. *l.* 10 *put out*, As the Radius to the fine of the Suns greatest declination 23. 31. *and write it thus*;

As Radius
To fine of the Suns greatest declination 23 31.
So is the fine of the Suns distance from the nearest Equator 16 960080
To the fine of the declination desired 10 4 964184
924254

p. 74. *there is a better figure in pag.* 51. *p.* 78. *the commaes should be left out, and l.* 10. *for* lines, *r.* times. *p.* 85. *l.* 33. *r.* a foot and an half long. *and l.* 36. *r. ferules. p.* 96. *l.* 29. *for* tre-sole, *r.* trefoot. *p.* 112. *l.* 20. *for* 32 82, *r.* 23 82.

In the *Appendix.*

Page 130. *line* 12. *for* square, *read* stroke. *l.* 15 *distinguish as* third: *at l.* 16. at that. *l* 25. *for* fines, *r.* fives *l* 30. *r.* 5, 10, 15. *l.* 33. *for* 38 *r.* 30. *p.* 135. *l.* 31. *for* 2. *r.* 12. *p.* 141. *l.* 20. *distinguish as* 8. *p.* 142. *l.* 9. *for* set, *r.* get.

The Faithfull Surveyour.

CHAP. I.

Of errours in Land-meaſure.

DIvers are of that opinion, That if two pieces of land are of equal peripherie, that thoſe two pieces are both of one and the ſame content. But that is eaſily diſcovered falſe; for let one piece of land lie in a true ſquare; being a quarter of a mile ſquare, or 80. poles ſquare, *viz.* a mile in all; the content is juſt 40. acres. For every one knowes, that 40. pole long, and 4. pole broad; or 80. pole long and 2. pole broad, make an acre. Therefore 80. pole long, and 80. pole broad, muſt needs make 40. acres, and that 80. times 80. is 6400. pole, which divided by 160. (the poles in an acre) is juſt 40. acres. But in a Circle of a mile about, *viz.* 320. pole, if (according to *Archimedes*) we multiply the Circumference by 7. which is 2240. and divide it by 22. it gives 101 $\frac{18}{22}$ the diameter: now then, if we multiply half the diameter 50 and $\frac{10}{22}$, or 50 and $\frac{10}{11}$ by half 320. the Circumference, *viz.* 160. (which are alſo the poles in an acre) firſt 160. by 50. is 50. acres: then multiply 160. by 10. *facit* 1600. which divide by 11. it gives 145. pole and $\frac{5}{11}$, ſo that the Circle contains more then the ſquare by more then a fifth part. And as in land, ſo in timber; and therefore that muſt needs be a falſe way of meaſuring round timber, to gird it about, and to take the fourth part thereof for the ſquare, as plainly appears in this; that, when they have hewed it, they make more of it then they made before. Alſo a ſquare is more capacious then an oblong; for every Shepherds boy can tell,

that if he hath but 24. hurdles in his fold, and that it goes upon a rood, where he hath but one at each end, and 11 on each side; his sheep will lie thicker a great deal, then if his fold goes six on each side, and end: though he knows not the proportion, yet he perceives a sensible difference; and so well he may, as being more then three to one ods. For it is as 11 to 36. for once 11. is but 11, and six times six is 36. And for want of this knowledge many surfeit their sheep in summer, by lying too hot. If I may advise, they shall never lay sheep thicker, then to allow 20. foot of ground to each sheep, so that if you have rod hurdles of 8. foot a piece, *viz.* 64. foot; in one hurdle square I would not put above 3. sheep and ½; nor in flat hurdles of nine foot long, above four sheep; and so doing, if your 24. nine foot hurdles go square, it may hold 96. sheep, and your 24. eight foot hurdles 84. sheep.

Another great errour I have known maintained by a great *Rabbi* Surveyour; that in measuring a triangle, it holds good to take the half of any side for the base, and the whole perpendicular from the angle opposite to that base, to the middle of that base, *& vice versâ*, and their product to give the content. But this is demonstrated to be false thus. In this oblong figure A B C D, let the two sides A B, and C D be 30 a piece, and the two sides A C, and B D 40 a piece, so 30 multiplied by 40. gives 1200. the content of this oblong, which is divided into two rectangle triangles, by the Hypotenuse A D, which two triangles A B D, and A C D are both equal; for that the sides A B, and C D are equal by construction, also the A C and B D are equal by construction, and A D is common to both; therefore the two angles B and C are equal: likewise the two triangles A B D, and A C D are equal, *per* 4. *prop. Element* the 1. *Axiom.* the 7. *Quæ ejusdem sunt dimidia, inter se sunt æqualia*: therefore either triangle must contain 600. Now in the triangle A C D, to discover the falshood, we must first finde the length of the line

line ED thus. First, ſquare the line CD, 30, *facit* 900. alſo ſquare CE, 20, *facit* 400; then C being a right angle, and we ſeek ED, the Hypotenuſe, we muſt adde 400, and 900, *facit* 1300, whoſe ſquare root is ED 36 $\frac{4}{73}$, multiply this by 20, the half of AC, *facit* 721, $\frac{1}{10}$, the content, too much almoſt by a ſixth part, being it ſhould be but 600. and ſo you ſhall finde it, if you multiply AC, 40. by half CD, 15. for the oblong AFHC, is equal to the oblong FBDH, therefore it is the half of ABCD. Alſo the triangle DGH, which is taken out of the triangle DCA, is equall to the triangle AFG, added to it.

Or if you will, make AD the baſe, upon which you may let fal a perpendicular from the angle C; but then it muſt not fall on the middle of the line, except it be the baſe of an Iſoſceles triangle; but if you will needs finde the true place of the field where the perpendicular muſt fal, I know no inſtrument you can work by, be it plain-Table, Theodelete, Quadrant, Circumferentor, no not ſo ſimple as the chain alone, but you may ſet out a ſquare by it; therefore ſet up your inſtrument in the ſtation-line, going forward ſtreight in it, till you ghueſſe that a line out of the angle will cut your ſtation-line ſquire-wiſe; which if you think you are far enough, ſet up your inſtrument there and firſt let it behold the mark you came from; if it doth not then behold alſo the mark you go to, you are out of your line, and muſt remove it ſide-wayes which having rectified it that way, then ſee if it look right into the corner: which if it do, it gives you the place in the ſtation-line deſired, which is 32 from A, and but 18. from D, *viz.* at I, which is thus made good. As the baſe 50. is to 70. the ſumme of 30, and 40 the two other ſides AC, and CD; ſo is the difference of the ſame two ſides 10, to 14, which 14 being taken out of 50, the whole baſe, the perpendicular ſhall fall on the middle of the remain 36, the half whereof is 18, to which adde 14, it makes 32 from A to I, as afore; and that taken out of 50 leaves ID, 18, as afore. Now to finde the length of the perpendicular CI, if you meaſure it in the field you will finde it 24 pole, which is thus proved. Take the ſquare of the ſide AI, 32, which is

1024. out of the ſquare of A C, 40, *viz.* 1600, reſts 576, whoſe ſquare root is 24, the perpendicular deſired. Now if you multiply 50 the whole baſe by 12. the half perpendicular: or 25. the half of 50. by 24, you have 600, as afore. Thus you ſee it double proved, that this way of taking the middle of the baſe for the fall of the perpendicular, is for the moſt part an extream falſe way: and the ſixth part of the ground and more may be eaſily got and loſt hereby: inſomuch that I have known by this very errour above twenty pounds got and loſt in one day between the buyer and ſeller, ſeverall times, and by ſeverall men. But whether *Balls* of *London* uſed this way, or worſe, I know not, who was ſent down by the Lady *Morriſon*, to ſurvey a Farm at *Hardwick* near *Shefford* in *Bedfordſhire*, whereof ſhe had let a new leaſe for 21 years to one *Childe* at five ſhillings the acre. *Balls* makes of it 400 acres juſt: *Childe* thinks himſelf wronged, ſends for me, deſiring me to meaſure it, not ſaying a word to me upon what terms, or that it had been meaſured before. I ſet to work, and having done, I give in mine account for 322 acres. He asked me if I would juſtifie it. I told him, I accounted him as my friend, I would ſtay for ſatisfaction a twelve-moneth; let him keep my plats, if in that time I were diſproved two acres, I would have nothing for doing it. Whereupon he works to the Lady to ſend another to meaſure it; but durſt not let her know he had meaſured it, but that his reapers, and mowers, nor his ſeed never gave it for ſo much. He prevails with her, ſhe ſends another; he meaſures it, knowing as little of any mans meaſuring, as I did of *Balls*. Upon his account we two differed but one rood in the whole thing, which he had made it leſſe then I did, by reaſon I meaſured half *Shefford*-brook more then he did. So I ſav'd him 19 pounds ten ſhillings *per annum*; which if it had been yearly payment, at ten in the hundred, as money was then, compound intereſt came to above 1200. pounds, but being half yearly payments, nine pounds 15 ſhillings, half yearely, 42 payments at five in the 100, which was the common reckoning both then and now ſtill for half a year, comes

to

to above 1300 pounds, a good Farmers eſtate. Therefore it behoves every man that hath, or may for himſelf or friend have occaſion to let or hire, buy or ſell land or timber, not to go on other mens legs, nor to ſee with another mans eyes, that have ſuch eaſie means to attain the skill of it themſelves. I make no doubt but that there are many Gentlemen, who have ſpent much time in the Univerſitie in Muſick, yea, and other ſtudies too, do wiſh at this day, (and more would wiſh, if they could ſee it) they had at leaſt ſpent ſome of that time in the Mathematicks; whereby they might have benefited both themſelves and their Countrey: which in commendations of it, *Pitiſcus* in his Preface to his book *Geodeticorum* ſaith, *Socrates hunc principalem Geometriæ finem eſſe ſtatuebat, ut agrum planum metiri, dividéque poſſit.* I have ſeen ſome ſpend eight years in learning Muſick; if they would beſtow but two years in the Mathematicks, it would have done them more good, and they might have done the Common-wealth good. Of all the ſeven liberal Sciences that may beſt be ſpared, as leaſt beneficial to a Common-wealth; and for my part, I had rather (if you will believe me) that my feet could pace 1000 acres of land of mine own, then my fingers to play 1000 leſſons on the beſt Lute in the town, though I might have it for my labour; and he that is not of my minde, it's pitie, if ever he have 1000 acres, but he ſhould change them for a fiddle. Recreation, I confeſſe, is good; but I would not have it made an occupation. They will account it ſmall recreation hereafter to be able to ſay, *Poſthabui tamen illorum mea ſeria ludo.*

Divers ſuch falſities I have ſeen; but I am loth to digreſſe too much. Divers other falſe ways there are; but I had rather I were come to lay down true ways, then to diſcover errours. Therefore that we take not a falſe way to our purpoſed end, we will ride ſtreight on to the next town; *viz.* the uncertain ways: where we muſt ſtay a little, and give our pen drink too, that ſo we may the eaſier finde the true way in ſuch uncertain ways.

Firſt, it is no certain way to lay a great deal of land upon a

little paper, as to work by the ſcale of 32. as many do, whereby upon each inch of paper they lay ſix acres, one rood, 24 pole; and it is an eaſie matter for a good Artiſt with good inſtruments to fail an acre in an hundred, much more with ſo ſmall a ſcale, and blunt compaſſes: neither is there any that ever I knew uſe ſo ſmall a ſcale, that can or dare ſay, that he is able to diſtinguiſh a quarter of a pole, whereby oft-times there is ſix in the hundred got and loſt, not in a year, but in a day.

Secondly, To truſt onely to the needle in any graduated inſtrument, as Circumferentor, Theodelete: and partly for fear of a loadſtone near; and alſo it is a hard matter by an ordinary needle, though of four or five inches long, to diſtinguiſh a degree, much leſſe five or ſix minutes.

Thirdly, For over-curious ways, ſuch as if I ſhall ſpend ſo much more time then ordinary, that the gain or loſſe will not countervail the time beſtowed on it: therefore as upon buying and ſelling there is ſome land of 20 or 40 pound the acre: ſome I have meaſured where every man in the town hath hired the tythe *communibus annis*, for two ſhillings *per* acre; others have undertook plowing for 2 ſhillings ſix pence, others have let for five ſhillings, as the Lady *Morriſon* aforeſaid. Now I will not ſtand ſo curiouſly upon that of five ſhillings *per* acre, nor work by ſo large a ſcale, as for that of 30 or 40 pounds the acre. This comes to five ſhillings the pole, the other very little above half a farthing a pole. Two pole got or loſt in the firſt is the Surveyour's ordinary dayes wages; whereas five acres of the other will but do it. Again, as there may be curioſity in meaſuring, ſo there may be in caſting: but let the ſame rule be the guide in both: and although *Pitiſcus* hath done exceeding learnedly through all his book, as like a Mathematick-Profeſſour, and well skilled in the doctrine of triangles; yet he that ſhall ſeek out his ſides, baſes, and perpendiculars by Sines, Tangents, or Logarithmes; or caſt them up by Logarithmes, as ſome others haue taught of late: yet neither *Pitiſcus* nor his followers have ſhewn themſelves practitioners; neither of them ever meaſured, plotted, and caſt 900 acres in three

three days, whereof for a mile together the ſide was as ſtreight as *Hockley*-brook, as the Proverb is: (for it was *Hockley*-brook it ſelf,) yet platted and caſt every crook; and ſo did I *Shefford* brook alſo: and Mr. *Wingate* hath meaſured 1000 on a day near *Biggleſwade* in *Bedfordſhire*. I denie not but theſe men may and have good skill in the Theorie, but as little in the Practick as the *Londoner*, that asked the countrey-Maltſter if malt did not grow upon trees. Such a *London* Mathematician (perhaps) was *Ball* aforeſaid, a perfect Surveyour, but never ſaw acre of land meaſured; ſo that he miſſed but 78 acres in 322.

CHAP. II.

Of making and keeping the field-book, and meaſuring paſture by the plain-Table.

§. 1. IF you intend to practiſe Surveying, make you a book of a quire of good ſtrong paper, ſo folded, that the breadth of the leaves may be in *octavo*, and the length thereof may be the length of two quarters, well bound with vellum, that you may lay it on your left arm to write: and if it be your firſt book that you have filled, write on the cover a great (A). If the ſecond (B). On the third (C). &c. Then page your firſt part of your book (A), all but ſome 12 leaves at the latter end, on each ſeverall page whereof you ſhall write a ſeverall letter of the Croſs-row in Alphabetical order, and ſo your book is ready to go to work.

How to chooſe their firſt ſtanding in Paſture-ground for the plain-Table.

§. 2. As ſoon as you come into the field make a mark, as ſome hole with a paddle-ſtaff, or ſtick up ſome paper, or both, at the firſt corner you come at; which if it be adjoyning in that place to another paſture, then chooſe your ſtation or hole (if be poſſible) that it may be right againſt ſome gap, gate, or ſtile

ſtile (which commonly in all paſtures there are near the corners, or elſe you will be forced to cut an hole through the hedg with a bill, that ſo from that ſtation you may ſee to the further ſide of that ground, or ſo far as you can, to ſtrike a line. But let that hole or mark be ſet four or five foot from any hedg or ditch, ſo that you may ſet up your inſtrument, and have firm ſtanding to ſee in a ſtreight line to the further ſide of the ground you are in, both on your left hand, and on your right: ſo that you touch not upon the hedges, nor incumber your ſelf with wood, buſhes, houſes, nor waters, though you are driven to go nine or ten poles off at one end, and but nine or ten links at the other. Whatſoever others bid you always go parallel to the hedge, regard it not; for if you do ſo, you ſhall have work enough till Wedneſday. What will theſe men do when they come at *Hackley*-brook? It will hold them a week to meaſure a furlong ſtreight, and they have no way left, but onely to equal one place with another by ghueſs; neither, alas poor men! do they know which way to go about to plot it; whereby though they do hit the true quantitie by chance, as the blinde man may ſhoot and hit a crow, is that a true plat of the form? and who knows not but brooks, rivers, & the very ſeas themſelves alter in time, witneſſe *Hercules*-pillers? and how can they go parallel by this whim-wham? Beſides, that by the plain-Table they do plot all as they go, ſo that they had need have a great deal of fair weather, no dewie mornings; and becauſe they know neither how to meaſure nor plot ſuch a piece, we have not had one that hath wrote of Surveying theſe thirty years, but have been all as mute as fiſhes in it.

CHAP.

PATENT OFFICE LIBRARY.

CHAP. III.

How to ſet down your notes in your Field-book, and to draw your ſtation-lines by the plain-Table.

HAving made choiſe of your firſt ſtation, before you begin to meaſure, take your field-book, & on the top of the firſt page write the name of the Pariſh firſt the ground lies in. Secondly, the year and day. Thirdly, the name of the cloſe. Fourthly, meaſured by me, and for *I. R. contra W. R.* or if you are indifferently hired on both ſides, write *inter I. D. & D. I.* Fifthly, your directour. Sixthly, your helper. And Seventhly, which way you went forward, whether *cum Sole*, or *contra Solem*: *Cum Sole* in a paſture is, when the hedge is on your left hand; *contra Solem*, when on the right.

Then in your field-book about two inches from the left ſide of the leaf, draw a line with your pen ſtreight down to the bottom of the leaf, and on the left ſide about an inch from the line write A, ſignifying the firſt ſtation, or the mark you ſtand on, and cloſe to it on the ſame ſide, write O, ſignifying the beginning of the line; then if you intend to go *contra Solem*, meaſure how many links are to the hedge or ditch on your right hand, and ſet them down right againſt A on the right ſide of the line; ſo all your lengths, as you go in the ſtation-line, muſt be ſet down on the left ſide of that down-right line, and all the breadths on the right ſide. Yet before you go forward, you muſt know theſe ſeveral things.

Prolegomena. Firſt, That always a ditch muſt be meaſured with that ground on which the hedge ſtandeth.

Secondly, That you never need ſet up your Table at A, unleſſe there be another cloſe adjoyning, which you are alſo to meaſure; nor yet at the laſt angle: ſo that if the ground have four angles, you need ſet up your inſtrument but at the ſecond and third; neither is there neceſſitie of ſetting it up at the third, if you be ſure you have meaſured all the ſtation-lines right, calling your Angles B C D E in order, &c. by reaſon you may ſet out the two laſt ſtation-lines of any ground whatſoever by the ſcale and compaſſes, by tranning the firſt of

them, and pricking the laſt, as ſhall be ſhown more at large, when we come to ſpeak of meaſuring by the chain onely.

Thirdly, If one of your ſides be buſhy, woody, watery, &c. that you cannot come at the hedge for ſuch things, leave that for the laſt, ſo that it be a ſtreight ſide; for your plot will give you that ſide: ſo that, if you have done all right thitherto, you cannot fail in that, neither need you meaſure it, ſave for triall ſake.

Fourthly, You muſt know, that whereſoever you have two cloſes to be meaſured joyning together, the ſtation-line in one cloſe ſerves alſo for the other, and the additions in one cloſe are the ſubtractions from the other.

Fifthly, If a fair plot in colours be required, you muſt ſtill, as you go in your ſtation-lines, take notice and ſet down in your field-book all Churches, houſes, rivers, ponds, gates, ways, paths, ſtiles, arbors, wind-mills, great ſingle trees, woods, &c. which fall within compaſſe of your plot or ſquare, and ſet them down in your diſtance from the ſtation-lines. If they be not on the ſame ſide of the ſtation-line that the hedge is on, mark them with a croſſe, and draw them all in your fair plot in proſpective in their proper colours, with their manner of ſituation, Eaſt or Weſt, North or South, and your needle in any of your inſtruments will help you always, making the North-ſide of your plot the over end, as you may ſee in plots of countreys; and at the bottom ſetting a ſcale of poles beautified with compartiments, and a pair of compaſſes: but your ſcale for this plot may (if the ground be very large) be ſmaller then that you meaſure by.

Sixthly, Before you begin you muſt make choiſe of your ſcale, wherein you are to conſider the bigneſſe of the ground, the bigneſſe of your paper, and the price or value of the ground, and whether on purchaſe, or hiring, and that for a longer or ſhorter time; yet howſoever it is good, though it be upon letting, not to be too careleſſe in it: for I have been imployed upon letting between Sir *John Crofts* and Sir *William Bryars*, yet before they concluded, they agreed on a purchaſe

by

by the acre upon the ſame meaſure; therefore I ſeldome meaſure upon purchaſe with a ſcale more then 8, never above 10 in the inch; nor upon hiring ſeldome above 10, never above 12.

Seventhly, Before you begin, you muſt conſider whereabouts of your ground you begin, that ſo turning the length of the Table to the longeſt way of the ground, and beginning at the like place of the paper as you do on the ground, you may (not taking too ſmall a ſcale) lay all that ground upon that ſheet of paper, or (at leaſt) all that you can meaſure that day; for it is ſomewhat troubleſome to ſhift your paper in the field, or to fall beſide it for a piece of a cloſe; for which, if you do, we will give you theſe five remedies.

1. If it be but a ſmall matter, and preſently comes on again, you may lift up the rulers, and that paper which they hold down cut it ſo, that ſo much as you need may lie upon the rulers.

2. If that will not be enough, you may make your ſtation-line that you came, or elſe do come on, ſhorter then indeed it ſhould be by 10 or 20 pole, taking the next angle upon the ſame line as if it were the end of it; and then making a new plot at home, your own reaſon will direct you better then I can ſhew it: for it is eaſier perceived upon triall in the field, then expreſſed by word or ſcheme; but then you muſt lay down none but ſtation-lines and angles.

3. The moſt common help that Surveyours uſe is to remove the paper nearer one end of the Table, and then with a piece of mouth-glue, which they uſually carry with them, they glue on what paper they think they ſhall need, and then faſten it down with the rulers again.

4. If your plain-Table be alſo a Pandoron, or have a ſemicircle, or a Quadrant, you may at any time, either in this caſe or caſe of moiſt weather, take off your paper, and help your ſelf thereby, as ſhall be ſhown hereafter.

5. By the chain onely and your field-book; whereof alſo hereafter in its place.

Eightly, Before you begin you muſt know, that both at the

beginning and ending of everyſtation-line, and every crook of the hedge, both inward and outward, you muſt meaſure the neareſt diſtance between the ſtation-line and the hedge (for all breadths muſt cut the ſtation-line ſquire-wiſe) and ſo make two right angles at the ſtation-line, and that is the beſt way: and ſo doing, all the pieces on the out-ſide the ſtation-line will be either rectangle triangles, or elſe compounded of an oblong and a rectangle triangle: the *area* of both which is found by adding the breadth at both ends together, and take ½ of it for the common breadth, which multiply by the whole length, and you have the content. And ſometime your beſt way to finde the ſhorteſt diſtance into an angle, is to ſet up the Table right in the ſtation-line: if ſtanding at the fore-mark you ſee by the edge of the Table the backer mark, and then ſtanding at the backer end you ſee the fore-mark, then are you right in the line. If now withall one or both of your other ſides look right into the angle, then are you right. And all theſe lines muſt be entred into your field-book, which fall perpendicular upon the ſtation-line, every one in their order on the right ſide of the line, and on the left ſide right againſt each of them their correſpondent lengths, how far each of them is off from the laſt ſtation. Or elſe you may ſtrike a ſtation-line into the angle, and ſo make *ſcalenum* triangles, but that is not ſo certain, and asks more labour.

Ninthly, Before you go forward you muſt propound to your ſelf a mark to go upon on the farther ſide the ground, or if it be quite beyond the ground, though it be a mile, it matters not: ſo that ſtanding at A you may ſee it clear from the hedge, yet as near to the hedge as you can; whether it be parallel or no, care not. If you can ſee no ſuch mark neither near the further ſide, nor beyond, then either you muſt ſend one before to ſtick up a ſtick with a cloth or paper on it; or to ſtand there till you come, with ſome white before his breaſt. And moreover ſee, if you can ſee ſome other mark between him and you right in the ſame line, be it either flower, weed, graſſe, dung, &c to be a guide for the fore-man, to keep him right in the line, that carrieth the fore-end of the chain. Tenthly,

Tenthly, Whereas you muſt have ten ſticks about a foot long apiece, whitled and ſharpned at the great end, let two take the chain, one at one end, the other at the other: let the former take the ſticks, and let him be ſure to lead ſtreight in the line, which for his guide therein he hath theſe helps. Firſt, he muſt always be right in the line with his two marks before him, till he comes at the firſt. Secondly, after he is come at the firſt, let him every time he ſticks down a ſtick, look backward to ſet himſelf right in a line with thoſe two. And thirdly, if there be no middle-man, let the hindmoſt ſtanding at A guide the foremoſt right in a line to B: and after the firſt chains length, let the hindmoſt guide the foremoſt, and the foremoſt the hindmoſt: for if the hindmoſt ſee the foremoſt right in a line between him and B, and the foremoſt ſee the hindmoſt right in the line between him and A, then are they both in the right line between A and B. Then, to go forward, let the foreman take all the ſticks, and tell them at the beginning at each change, and at the end (for the moſt common miſtake is the loſing or mis-telling of a ſtick) and carry all ſave one in his left hand, and that one and the chain in his right, and let him go on ſtreight in his ſtation-line, not looking behinde him till he feel the chain check him, then ſtick down that ſtick, and away as faſt you can run, and as you go ſhift an other ſtick into the right hand ready to ſtick down again. In the mean time the hinder-man, firſt holding the chain in his right hand at A, let him look the chain be not tangled, and away on till he come to the ſtick, and then clapping his ring of the chain to the foreſide of the ſtick, let him take it up with the ſame hand he carrieth the chain, and away after his leader. And when the ſticks are all run, and that they are not yet at the end of that ſtation-line, let the fore-man run one chain more, holding ſtill the ring in his hand; and at the end thereof ſet his toe, there ſtanding ſtill; and let the hinder-man take up the tenth ſtick, and hold that ſtill in one hand and the other nine in the other, and deliver the nine to the fore-man, ſetting his toe to the fore-mans: then let the

How to ſet themſelves right in a line.

fore-man tell the nine, and, if they be right, away; if not, you muſt meaſure all that courſe again, and ſeek the ſtick; for you know not which of you loſt it; and ſo going to the end of that ſtation-line, or within ſo much of the end of it, that you may have libertie to ſet up the Table, and ſee to the further end of the next ſtation-line, as you did at A, without any incumbrances; which, if you work by a diagonall ſcale, may be in any place; but if by a plain ſcale, you had beſt to have it at ſome even poles; and becauſe by *Gunther's* chain of an hundred links (which is the beſt way) you work not by the diagonall ſcale, by links, but by the foot chain, by the decimall ſcale, and by poles, and parts of poles. Set that length in your note-book, on the left ſide of the line, cloſe by the line, and a B right under A; and on the right ſide the line write, [*ſtation*]. Then go on ſtill in the ſaid line, till you come to the out-ſide of the ground, which in paſture will always be beyond the ſtation; but in woods ſhort of it. Set down that length alſo on the left hand, and the breadth from the ſtation-line at the end thereof, to the hedges you came by on the right; and then draw a line croſſe over your book, and ſo at the end of every other ſtation-line. But you muſt not forget, that all along as you come you take (as I ſaid before) the breadths from the ſtation-line to the hedge, both at the beginning and ending, and every crook both inward and outward, with their correſpondent lengths, and to ſet them down as afore. Alſo, if a fair plot in colours be required, it will be needfull to ſet down the true lengths of each ſtation-line to every mans hedge that ſhoots upon your plot, beſide the ornaments, that you may ſhew part of their corners, as alſo in caſe they are their grounds that imploy you in it. And ſometime alſo, if you are to meaſure two cloſes being together, and that you would come forth upon that point in the ſtation-line, it will alſo be needfull to ſet it down in your note-book, and often ſave labour marking it with an X.

Now if you begin at A, and have two cloſes lie there together to be meaſured, then take up your Table there, and having

ving turned the length of the Table to the length of the ground, and proportioned the A of your Table to the A of the ground, ſet up your ſights with the ruler upon the Table, and having ſcrewed it faſt, turn them upon the Table, till you ſee the mark at B. Alſo ſee ſome mark in the cloſe adjoyning on the further ſide, or a mile beyond: and becauſe I ſee juſt there begins a triangle on the right hand, which falls ſhort of the length of the other line, therefore I draw a third ſtation-line from A, repreſenting the right-ſide line of that triangle; ſo I leave that cloſe till I have made an end of the other; ſo having drawn my line AB, I go to meaſuring it by *Gunther's* chain, and I finde at O of the line A B are five links to the hedge, I enter them as afore. At 200. I croſſe a path, which I enter next on the left ſide; but becauſe there is no crook in the hedge right againſt it, therefore I take no breadth, but write (*path-gap.*) At 437. the breadth is 60. I ſet them down, becauſe here is both a crook, and right againſt the parting of two cloſes that ſhoot upon this: thirdly, it is right againſt a gap to come out from the further end of the firſt line in the ſecond cloſe, whereby meaſuring that and 75. links of another ſtation-line, and ſetting up the Table twice, that cloſe will be meaſured, as ſhall be ſeen anon: fourthly, it will be a good place to make choiſe of, to ſave us ſome labour in teaching to meaſure by the chain onely, as ſhall be ſhown in it's due place. Hence I go on to 900. there I chooſe my next ſtation, both becauſe if I do go further, my next ſtation-line, B C, will be incumbred with the hedge, as alſo I ſhall have no ground to ſet the Table on; but here I take no breadth, being the hedge goeth out ſtreight to the end: onely I ſet down 900 ſtation, and then meaſure ſtreight on to the out-ſide 907. where the breadth is 8. ſo I ſet down 907. on the left hand, and 8 on the right, *out*, that is, without the ground. Then having finiſhed A B, I ſtrike a line croſſe the book, and ſet up my Table again at B, and having made choiſe of my ſcale, which I made no uſe of till this ſecond ſtation, I take off 900. with my compaſſes from the ſcale, and ſet it in that firſt ſtation-line from A, where I

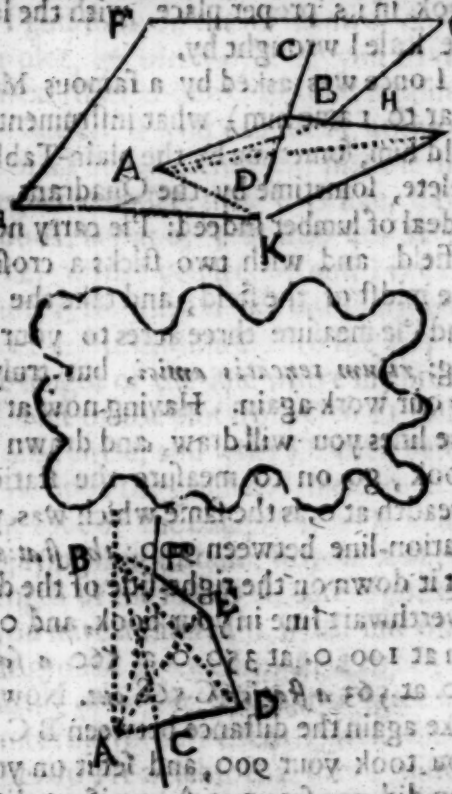
make

make a prick, and a little roundle round about it, as alſo at A. And here I write B; and now that which was forgotten at A, do now: *viz.* one thing was, to take notice what degree the South-end of the needle bore upon at A: for if there be no errour, it will bear upon that degree quite through the plot, unleſſe you remove the paper. And a ſecond thing is, if you are to give in a fair plot in colours, it will be needfull to ſtrike a meridian-line through the plot, unleſſe you lay the North-end of the needle upon the *Flowre-de-lice*, which, in caſe a fair plot be required, I confeſſe, is the beſt way: for ſo you ſhall draw your plot in the field according to the four windes, whoſe borders ſhall be parallel to the edges of the Table.

Now having ſet up your Table at B, lay your ruler with ſights upon the line A B, directly placing your ſelf between the Table and the end of the line, and your face toward A, in ſuch a poſture as if you were diſcharging a muſket, and winking with one eye, having both your hands on the two corners of the Table next you, turn the Table till through the ſights you ſee the mark at A: then ſcrue the Table faſt, that it turn no more, and turning your back to the hedge you came by, having propounded to your ſelf another mark to go to at the further ſide of the ground, by the next hedge-ſide, as you did at A, lay your ruler cloſe to the prick B, with that end next you, and keeping one point of your compaſſes, or needle, or ſcriver, in that prick with your right hand, and the ruler cloſe to it, lay your left hand, being ſpread, upon it, and turn the further end of it, till through both the ſights you ſee that mark at C, and then holding it ſtedfaſt with your left hand draw that ſtation-line B C alſo. Now if when you were at A, you had ſet up a mark at C, and another at D, and ſtroke A C and A D: and thus now alſo you had here at B ſtruck B D, as well as B C, being the cloſe hath but four angles; you need not have ſet up your Table any more, no, though you had but ſtruck A D, nor yet have meaſured any more of it, if you be ſure the hedges be all ſtreight, (which is ſeldome ſeen in antient incloſure) and that the marks at C

and

and D be ſet juſt in the angles. This way, I confeſſe, is ſomething quicker then to go round about, but not ſo exact: yet this way one Mr. *Sheppard* of *Maldon* in *Bedfordſhire* uſed, who formerly was my Scholar, and who ought *Redburn*-Parſonage in *Hartfordſhire*, letting every man his tythes at two ſhillings *per* acre *communibus annis*. He took me along with him, and each of us a plain-Table, and finding almoſt all, four-corner'd cloſes, and ſtreight hedges, we meaſured but one line in each ground. And indeed, where breadth and lengths are near equal, there will be no great danger; but where there is much odds, they will make ſuch acute angles, that there will be no truſt to them, the lines running ſo one in another, as it is hard to ſay where they cut; and therefore ſuch as have ſtuffit their books with ſuch whimſies, ſhall give me leave to laugh at them. Some ſhew how to meaſure the depth of a Well (but that is not well) by the plain-table; others teach to meaſure a piece of ground at two ſtations, 9 or 10 pole aſunder, in the middle of the ground; but there is no truſt to any of thoſe ways, that give ſuch acute angles. Let the talk of never ſo many ways, this one way of going round is *inſtar omnium*. Whether they take the line A B or C D in this firſt figure for their ſtation-line, they ſhall never make good work of it. And what will they do in ſuch a figure as the ſecond?



C I con-

I confeſſe, in ſuch a caſe as the third figure, if there be a *trapezium* on the out-ſide of my ſtation-line, ſuch as C D E F; & ſuppoſe my ordinarie ſtation-line to be A B, ſometimes I uſe this way. Right againſt the hedg C D, I ſet up the Table at A, and having placed the Table in his right ſituation, I ſtrike theſe three lines, A D, A E, and A F, and then meaſure on from A to B, and then ſet up again, and then again I ſtrike B C, B D, and B E, and never meaſure any of thoſe ſix. And after the ſame manner, if I have a good large triangle on the out ſide of my ſtation-line, if my ſtation line be one ſide thereof. But in this caſe, when I come at home, if I determine to keep my note book and to draw a plot of it 20 or 30 years after; I then draw the like figure in my field-book in its proper place, with the length of each line, and the ſcale I wrought by.

I once was asked by a famous Mathematician (but I forbear to name him) what inſtruments I uſe to meaſure by? I told him, ſometime by the plain-Table, ſometime the Theodelete, ſometime by the Quadrant, &c. Quoth he, There is a deal of lumber indeed: I'le carry nothing but an high ſtool a field, and with two ſticks a croſs I'le ſtand upon that in the midſt of the field, and take the diſtances to every angle, and I'le meaſure three acres to your one. I gave him his saying: *riſum teneatis amici*, but truly I could not. But let us to our work again. Having now at your ſtation B drawn all the lines you will draw, and drawn a line croſs your field-book, go on to meaſure the ſtation-line B C, where the breadth at 0. is the ſame which was your diſtance in your laſt ſtation-line between 900. *the ſtation*, and 907 *out*: *viz.* 7. ſet it down on the right-ſide of the down-right line under the overthwart line in your book, and 0. in the left-ſide, then go on at 100 0. at 350 0. at 560 *a ſquare ſtroke into the angle* 30. at 563 *a ſtation* C 568 *out*. Now having finiſhed this line, take again the diſtance between B C, 563, upon the ſame ſcale you took your 900, and ſet it on your plot from B. Then if you did not ſet up at A, or if you did not draw the line D A when

when you were at A, but that there wants two outside-lines to draw ſtill, then ſet up your Table again at C, and laying your ruler on the line B C, turn the Table till through the ſights you ſee the mark B, which if you do, then ſee if the South-end of the needle do ſtrike the ſame degree it did at A and B: if not, there is ſome fault, which moſt commonly is in the laſt line ſave one, and muſt be rectified before you go further.

But there is a ſecond way of triall infinitely better, which is this; Having placed C B line right upon B, lay your ruler upon the two pricks C and A, if then through the ſights you ſee A, all is right; if there be a fault, it is commonly in the length of the laſt ſtation-line ſave one, which if you came *contra Solem*, and your ſights look on the left hand of A, your book is more then your plot, *& vice verſâ*. If you have rectified it, ſet out your next ſtation-line C D, and meaſure as afore, and make your ſtation, if you can ſee A, at the very end, and can go free from all impediments: elſe make it ſhort as afore. And then begin to meaſure that C D line, having drawn a line croſs the book, ſay at 0, 5. at 200 40, at 200 10, at 656 *out, ſtation* 12. Where you ſee, becauſe I need not to ſet up my Table any more, for there is but one line more to meaſure; therefore I drive the ſtation-line C D to the very outſide; ſo I take the whole length of the line where my breadth is 12. This length 625. I ſet on the plot from C to D, where I make a prick within a little circle, and write D: then before I meaſure the laſt line D A upon the ground, I meaſure it firſt upon the plot, ſetting one foot of the compaſſes in D, and the other in A; and then applying that diſtance to your ſcale, that will give you the true length of the line D A, before you meaſure it. So that when you have meaſured it, if the line on the plot and the line on the ground agree, then all is right; and this we call the true ſhutting of a plot, which if it agree within a pole, or 20 links, moſt Surveyours count it well ſhut: I think it too much, neither do I remember that ever I miſſed ſo much in all my life. I once meaſured a wood called *Horſley-*

wood in *Luton*-Pariſh for Judge *Crawley*, where one Maſter *Lawrence* was my Antagoniſt for Sr. *Robert Napier*: he puts me to meaſure it, and he goes by and takes the angles as I drew, and ſet them down in his field-book; but ſeeing that we were forced to make 14 ſtation-lines, and hilly ground too, he offered to wager five ſhillings, that I ſhould not ſhut within five pole; I offered to accept it: in regard whereof at the laſt ſtation, I giving him the diſtance on the plot, would needs ſet my Table to try what hopes that gave me, and finding it ſtroke right upon my A, I then offered to take his wager, to ſhut within a yard; but I miſs'd not a foot. We two had been four times Antagoniſts for the ſame men before, one after another, and our greateſt difference was never but five pole at a time in ſixty or ſeventy acres.

An Example.

We will give you now an example of the Field-book, and plot of three cloſes lying together, partly reall, and partly ſuppoſed.

Cheſterton, Cambridgeſhire, June 21. 1656.

Meaſured by me *G. A.* three cloſes, called *Church-cloſes*, I for *A. B*, *John Dampot* for *C. D.* upon purchaſe, *S. L.* directour. I begin with the Eaſt-cloſe at North-Weſt, going *contra Solem*.

Links

Links in length.	Links in breadth.	
A 05		
200	a path.	
X right a- 435	60	14137
gainſt a hedge.		
B 900	ſtation	
907	out. 7	15742
07		
100	0	350
356	0	00000
560	into angle	30. 3150
C 563	ſtation	
568	0 out	120
05		
200	40	450
200	10 theſe 2 breadths are both in one place.	
D 656	out. ſtation	10. 4560.
A 00		
500	0	0000
740	meets A 15.	1837
745	out. the N. W. cloſe enters.	
	all the borders	40346

Subtende.	
C X	674
D X	756

N. W. cloſe enters at 5 from A Weſtward.

A parallel by the North hedge of 15. next ſtation-line A E.

Next ſtation-line A F G.

A	00	
F	650	50. ſtat-lin. F E
G	825	60
	850	out 0.

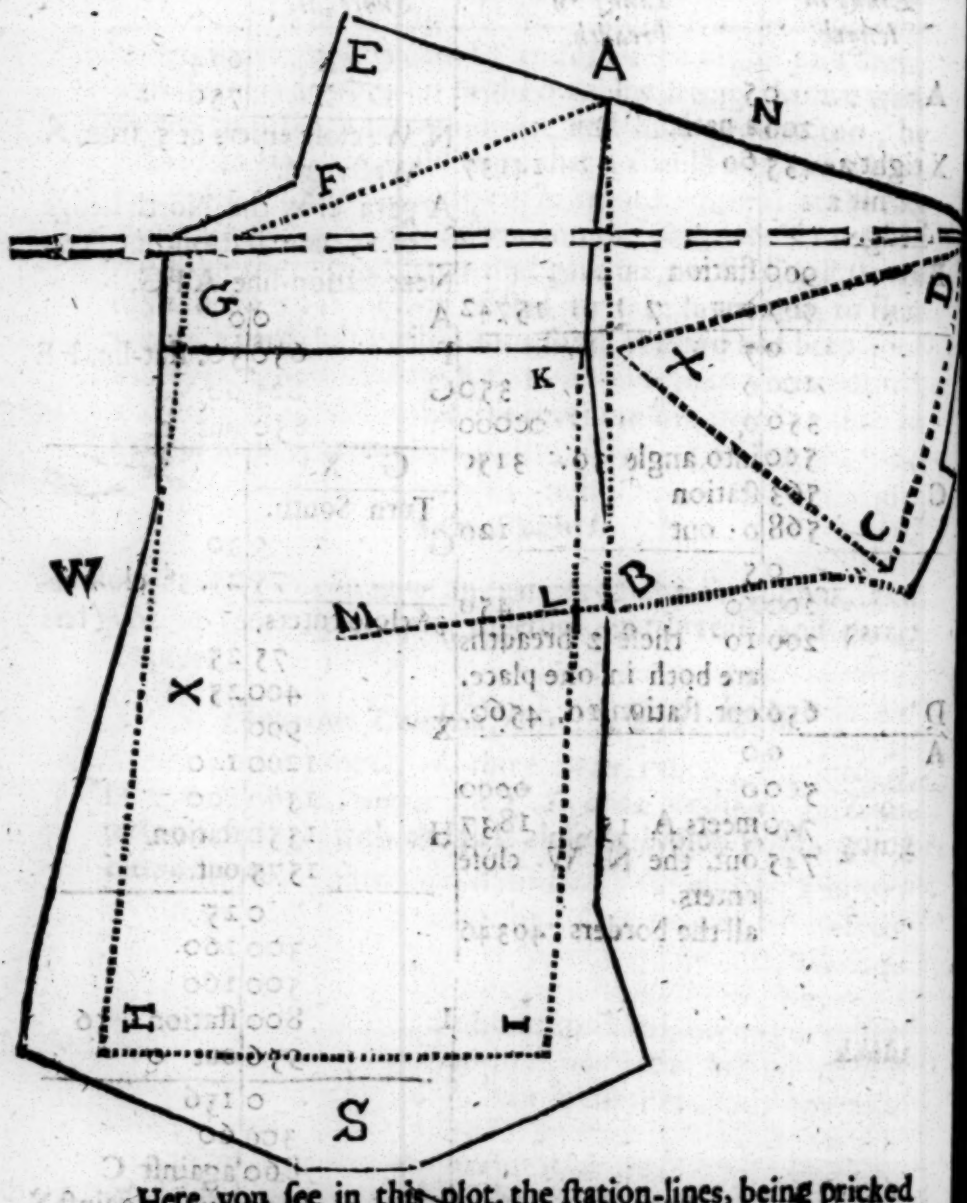
G X 1

Turn South.

G	030	
	75	25. 3d cloſe enters.
3d cloſe enters,		
	75	25
	400	25
X	900	
	1200	140
	1500	200
H	1550	ſtation.
	1575	out.
	025	
	300	160
	500	160
I	800	ſtation. 56
	956	out 0
	0156	
	300	60
	860	againſt C
	1340	out 0. againſt X

Suptend from out, to X 1090.

thence to I. 947.



Here you ſee in this plot, the ſtation-lines, being pricked lines, are not drawn parallel to the hedges, or out-ſides of the ground: if we ſhould do ſo, how many ſtations ſhould we make

make in ſtead of that line I L? Likewiſe we muſt make three for C D; yet theſe are nothing to *Hockley*-brook.

Beſides, in working this way my ſtation-lines cut one another more perpendicular, then any other way whatſoever, which is much to be regarded in working by the plain-Table. The onely way to take an acute angle, is with graduated inſtruments to take the quantitie of the angle, and to calculate it by ſines and tangents by the doctrine of triangles; but he that goeth that way to work, may chance to meaſure ten acres, whileſt another doth an hundred. Adde hereto that I can more eaſily ſee every crook in the hedge in going round, then any other way.

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Of plotting at home, and of ſeverall ways.

THey that uſe to go parallel to the hedges do ſeldome uſe any field-book, but plot as they go by the plain-Table, becauſe they ſuppoſe themſelves to go in the hedges, and therefore allow a parallel from the hedge; but if at any time they cannot go parallel, by reaſon of houſes, waters, buſhes, or the like, then they are much troubled, and muſt of neceſſity plot as they go, for want of a field-book: whereby they ſpend much more time abroad, both they & their helpers, then they need, & which they themſelves might do in half the while at home; beſides that, the leaſt miſt drives them out of the field: for though they could meaſure by the chain onely (which I am ſure was never heretofore publiſhed by any, but hath ever been thought a thing impoſſible to plot and prove a plot by: of which (God willing) hereafter;) yet can they no way help themſelves for want of a field-book alſo; the form whereof being already laid down unto you, together with the plot to which it belongeth, being compared together will direct you better then many words; yet becauſe I deſire to make all things ſo plain, that we may be ſure you can ſtick at nothing, we will lead you through one line, and then turn you foot-looſe.

Firſt,

First therefore, if you have not yet done in the field, and the weather ſerves, & your helpers are ready, then take your plot off your Table, and cover it with a new ſheet of paper, and away into the field; loſe no time there, eſpecially if you are far from home; for you may plot & caſt at all times at home, but you cannot always meaſure in the field. But if otherwiſe, then take your Table from his foot, & the ſocket from the Table & your plot ſtill upon it, lay your field-book before you, and take your ſcale and compaſſes in your hand, and begining at A, both of your book and plot, ſeeing 5 (which ſignifies 5 linkes in breadth) is right againſt A on the right-ſide of the line, and that you go *contra Solem*, which gives the hedge you go by to B on the right hand; therefore take thoſe 5 with your compaſſes from off the ſame ſcale you laid down your ſtation-line by, and ſet them from A to the right hand, which although you work by a ſcale of 8 or 10 in the inch, you cannot take with your compaſſes, therefore ghueſs at them, and then make a prick. Next take with your compaſſes your next length on your left hand, which is 200, that ſet in the ſtation-line from A, that is ſet one foot in A (as you muſt doe likewiſe with all the other lengths) and the other where it falls in the ſaid ſtation-line toward B, but becauſe there is no crooke of the hedge, either inward or outward, ſave only the path, which ſhewes that there you croſs'd the path, therefore onely draw a ſtroke, or two if it be broad, croſs the ſtation-line. Then take your next length 43 5 and ſet it likewiſe in the ſtation-line from A towards B, and for that right againſt it you have 60 breadth, therefore take 60 and ſet on the right hand of your ſtation-line, and becauſe I ſee alſo (*hedge*) it tells me that a parting hedge of two cloſes ſhot right againſt that 60, therefore I give a little touch with my pen, till I come to ſet out the reſt of it in the other cloſes. My next length, being my ſtation 900 B, is ſet out already. Laſtly, becauſe my laſt length is 907, that is 7 beyond 900, and that the breadth againſt it is 7 alſo, therefore take 7 with your compaſſes, and ſet it both forward and on the right-ſide,

and

and thus have you pricked out the hedges againſt this ſtation-line. Now you muſt draw lines with your ſcale and compaſſes from pricke to pricke, and then with ink: ſo theſe parcells between the line and the hedge muſt be additions to that within the ſtation-lines to this firſt cloſe; but ſubtractions from the other where one ſtation-line ſerves to two cloſes, as that part of A B from A to 435 doth both for this and the next.

CHAP. V.

Of calculation or caſting up.

The figures or parts to be meaſured are either ſquares, oblongs, triangles or *trapezias*, ſuch as are compounded of an oblong and a triangle. For the ſquare, and the oblong, one rule may ſerve both, *viz.* multiply the breadth in the length.

Triangles are of divers ſorts, we make uſe onely of two the rectangle and the *ſcalenum*, the rectangle without the ſtation-lines, the *ſcalenum* within. For the rectangle and *trapezium* one rule will ſerve both, at leaſt thoſe *trapezia* which have two right angles at the ſtation-line. Add the breath at both ends together, take half for the common breadth, & multiply it by the length theſe breadths and lenghts our book will give us. For *ſcalenums* within the ſtation-lines the way is thus. Look how many angles your ſtation-lines do make, ſo many triangles will there be ſave two, by drawing diagonall lines from corner to corner; theſe diagonalls are fitteſt for your baſes: unleſs if it be a ſingle triangle, then commonly the longeſt ſide. Take the length of your baſe therefore with your compaſſes, and apply it to your ſcale, and what it gives ſet it down, take alſo the ſhorteſt diſtance between the angle oppoſite to that baſe and the baſe it ſelf, apply it alſo to the ſcale, and what it gives ſet down alſo; now take half the baſe and all the perpendicular, or half the perpendicular and all the baſe, and multiply one by the other, ſo have you the content of that triangle. But commonly where there are more angles then three, one baſe will ſerve two triangles, and add both perpendicu-

lars together, and take half of both and the whole baſe, or half the baſe & both them, and multiply: ſo have you the contents of both triangles.

And thus ſhall you caſt up all your out-borders, juſt as you found them by the chain; & many times the baſes of your triangles alſo. So that by this way it is impoſsible to fail much, if any heed be taken; whereas by the common way of plotting without a field-book it is almoſt impoſsible, to come near the truth; eſpecially working by ſo ſmall a ſcale, as I have known ſome do, mixing thoſe crooks without with the triangles within: ſo that they loſe wholy the benefit of their meaſuring by the chain; not taking one line as they meaſured it, they truſt rather to taking up their out-ſide lines by the ſcale and compaſses, then to their chain: & yet they will confeſs, that with the ſcale of 32 in the inch (which I have known a famous Artiſt uſe in no great ground) that they cannot diſtinguiſh a quarter of a pole. So a quarter miſs'd at laying down, and a quarter at taking up, there is half a pole miſs'd in the length of each perpendicular, and as much in each baſe; and theſe multiplyed, I ſee not, but a man may paſe a ground as near the truth as they. And thus in general.

We will now come to the particular parts, and firſt of the outſides. We ſhewed even now how an oblong muſt be meaſured by multiplying the breadth by the length; and likewiſe the rectangle triangle, and *trapezia*, by adding both ends together and taking the half for the mean breadth.

Now therefore in the firſt cloſe begining at A ſubtract the firſt length 0 out of the next, againſt which you find a breadth viz. 435, there remains the length of that rectangled *trapezium* 435, and for the breadth of it, add the firſt breadth 5, to the next 60, it makes 65, the half whereof is 32 $\frac{1}{2}$, which multiplied by 435, gives 14137, the content of that *trapezium* to be ſet againſt the latter of the two numbers or breadths 60. Where note by the way, that you ſhall never have any other fraction to multiply by but $\frac{1}{2}$, and for that you muſt work from the left hand to the right, ſaying, Half 4 is 2, half 3 is 1, half

half 15 is 7, as here you ſee.

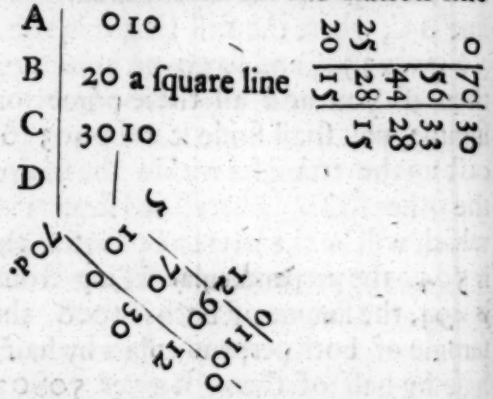
Then again take your laſt length 435 out of 907 (for you have no breadth at 900) reſts 472, the length of that *trapezium*, alſo add your two breadths, 60 and 7 together make 67: (for every middle breadth of each ſtation-line muſt be twice added, ſave where you have two ſeverall breadths fall in one place, as in the line C D, where you have the length 200. twice together) the half of 67 is 33 ½, by which multiply 472, *facit* 15742 to be ſet againſt the latter breadth 7. Then go to the ſecond line B C, where the firſt length is 100, the common breadth 3 ½ gives 350, and ſo go on according as the example gives: then if you add all thoſe primes or ſquare links into one ſumme, you ſhall finde it to be 40346, that keep till you have caſt up the triangles within the ſtation lines, and likewiſe all the other ſlabs. Therefore I draw a diagonall from A to C, which will be the baſe to both triangles, and half the length is 504. the perpendicular falling from B is 514, that from D is 494, the ſumme of both is 1008. then theſe multiplied, the ſumme of both perpendiculars by half the baſe, or the whole baſe by half of them, it gives 508032, which added to the ſumme of the borders 40346, it makes that firſt cloſe to give 548378 ſquare links in all. Now to bring theſe links into acres, you need but onely cut off the five right hand figures, the reſt to the left hand are acres, *viz.* five acres: the reaſon is, there are 25 links in the length of a pole, that ſquared gives 625 ſquare links in a pole, and that multiplied by 160 (the poles in an acre) gives 100000 links, by which divide your ſumme of your links, or for the five cyphers cut off five places, the reſt are acres; and the five ſo cut off are the numerator of a fraction of an acre, whoſe denominator is 100000. So 548378 gives five acres.

435
32 2
870
1305
217
14137

Now to bring theſe five figures into poles, you may either divide them by 625 the primes in a pole: or elſe multiply thoſe two of the five next the left-hand always by ſix, and ſet them

a place nearer the right-hand, and then add thoſe two which you multiplied, and the two which are under them together, and increaſing them ſo many unites as are fixes in the next two, and you ſhall have 7 pole and 253 links..

If now that when you have caſt up a cloſe you have more then half 625 primes remaining; ordinarily it is accounted for a pole: if leſſe, then for nothing. But if you have more cloſes adjoyning, you may reckon it with the next cloſe. Suppoſe your ground hath the out-ſide of this form, whoſe ſtation-line is A D, you may ſet it down in words thus in your note-book. At A it is 10 to the brook from the ſtation-line 0, at B where I have gone 20 poſe in the ſtation-line, there is a ſquare line to a crook ſtroke with the edge of the table, in which at 15 on the left hand is 20, at 28 is 25 on the left hand, and 15 on the right hand; at 44 is 28 on the right hand, at 56 is 33 on the right hand, at 70 is 0. on the left, and 30 on the right hand: then at 30 in the ſtation-line is 10, at which 30 alſo I ſtrike a ſtation-line forward, which when I have ſtroke it, I finde the fore-moſt acute angle by my ſcale of chords to be 70 degrees, that alſo I enter in my book: by help whereof and a diagonall line from angle to angle, I can draw the plot of any ground, though many years after, without going to it again.



And after the ſame manner you may plot and ſet down ſingle lands in the common-field, or a cloſe that is narrow and long.

CHAP.

CHAP. VI.

Of meaſuring a Wood.

THe difference of meaſuring a wood and paſture is in theſe two things: Firſt, in paſture you meaſure on the in-ſide, but woods on the out-ſide. Secondly, in paſture all your *trapezia* are to be added to that within the ſtation-lines, unleſſe your ſtation-line be in the circle adjoyning; but in this to be ſubtracted.

CHAP. VII.

Of dividing or laying out of ground.

OF this there are three degrees, each more difficult then other. The firſt is when the length of a ground is given, and a given quantity deſired; as if you would lay out two acres of graſs in a paſture which is 36 pole long, and you deſire the breath: Firſt, I turn my two acres into ſquare links, it is 200000, which I divide by 900. (for 25 times 36 is 900) it gives 224 $\frac{1}{4}$, the which if you divide by 25, the links in a pole, it gives 8 pole 22 $\frac{1}{4}$ links in breadth, and this needs no plotting. Or, if you would do by the foot-chain, ſay two acres is 320 pole, that divided by your length 36, gives 8 pole and $\frac{32}{36}$, which abbreviated is $\frac{8}{9}$: and to know how many half-feet that is, becauſe there are 33 half-feet in a pole, therefore I multiply 33 by 8, *facit* 264, that divide by 9, gives 29 half feet, and $\frac{1}{9}$ or $\frac{1}{3}$, that is, 8 pole, 14 feet, 8 inches.

Secondly, In paſture-ground, ſuppoſe a paſture with crooked hedges is equally to be divided between two men. Firſt I plot it and find it 52 acres, 2 roods, 10 pole, that is 26 acres, 1 rood, 5 pole a peice: I ghueſs as near as I can to ſtrike a line over the middle of my plot, but meaſuring one end upon the plot, I finde it wants 264 pole of his due; therefore I meaſure the length of the dividing line, which I finde to be 56 poles. Now to work by the decimal chain, I multiply 264, my poles

wanting by 625, the ſquare links in a pole, they make 165000 likewiſe I multiply 56 pole, the length, by 25, the links in a poles length, they make 1400, by which divide 165000, it quotes 117 $\frac{5}{7}$: that is 4 poles 17 $\frac{5}{7}$ links. But by the foot-chain, if you divide 264 by 56, it quotes 4 poles and $\frac{40}{56}$: which to bring into half-feet, multiply the numerator 40 by 33 the $\frac{1}{2}$ feet in a pole, *facit* 1320, which divide by 56, it gives 28 half-feet and $\frac{16}{56}$ of a half-foot, *in toto* 4 pole, 14 feet, 2 inches almoſt. And ſo much muſt you remove your dividing line at both ends: and this may be done as well on the out-ſide as on the in-ſide,

Thirdly, To divide a ſtanding wood of 200 or 300 acres, and to drive a ſtreight line from a mark on one ſide thereof to any mark on the other, though the wood be twenty years growth, and a hill in the midſt; A rare ſecret.

Be ſure to plot and meaſure enough, or more, then you deſire to take out of it, and where you intend your dividing-line ſhall come, there, in your ſtation-line, on the firſt ſide ſet a mark, keeping alſo good marks at every ſtation, ſo going on till you be ſure you are far enough on the other ſide alſo. Then draw your dividing-line by ghueſs, keeping one end thereof ſtill upon the mark in your ſtation-line, then meaſure that part upon the plot, as in the former ground, and add or ſubtract from your dividing-line as before; ſave that here you need not remove the further end, if the difference be but ſmall, but double the breadth at the laſt. But if you rather think fit to remove both ends, your beſt way is to do it firſt on your plot, and make that perfect, and then draw your new line quite through to the ſtation-line on both ſides. But there is the myſterie, how ſhall I give directions how in my abſence to drive a ſtreight line croſs the wood from a mark in this ſtation-line to a mark in the other on the other ſide, through ſtanding wood of 20 years growth, and a hill in the midſt, as once I laid out 60 acres of *Wilſteed-wood* being 160 acres between Sr. *Thomas Hillersden* and Sr. *Oliver Luke*; and another time in a wood at *Hytchin*. But not to detein you. If you work

work by the plain-Table, look which ſide is cleareſt from impediments, that you may go ſome 10 or 12 pole outward from the wood, then ſet up your Table at that point in your ſtation-line, that your dividing-line falleth upon, & laying your *index* on the laſt ſtation-line, turn your Table, till through the ſights you ſee either your laſt ſtation before that, if it be not too near, and having lengthned out your dividing-line as far as poſſibly you can, lay your *index* upon that lengthened line, turn your back to the wood, & ſending one before ſome 10 or 12 pole, let him there move to and fro ſidewiſe as you ſhall direct him by looking through the ſights, and then at both your ſtandings drive good ſtakes, or lay ſtones, or make holes; ſo a line driven through the wood continued ſtreight with theſe two will carry you to your firſt mark in the other ſide, if you did not remove that end; or if you did, then to that mark, where now you muſt ſet it: ſo that look how much you removed it forward or backward in the plot, ſo and ſo much muſt you remove it here alſo; and then ſet a good mark here alſo. But if when you have placed your Table on your ſtation-line as before, there is but little ſpace left to draw your directing-line, you may, and indeed far better, lay your *index* all along your dividing line and by it direct your man.

CHAP. VIII.

To meaſure arable-common-field-ground.

IN divers countreys much arable lying in common fields lyeth in ſmall parcells, ſome places an acre, ſome places half an acre, and ſome places a rood, and that ſo crooked, that none will deſire a plot of ſuch ground; yet, for as much as a man in time may have his rood grown to half a rood, by his neighbours plowing of it away, and to find at any time afterward, if it be ſo diminiſhed or not, and in what place: you ſhall ſet it down in your field-book in this manner.

"*Cheſterton. Eaſt-field* in *Broad-oake-furlong.* Begin on "the Eaſt-ſide of the furlong three lands *per* eſtimate three

'half

" half-acres. T A on the East, G D West, coppy of Dame
" *Anne:* begin North at 0, 106 at 400 163. at 400 more 101,
" at 346 *out* 100, conteining 134500 (that is) one acre 55 pole
" 125 links. One rood more in the same furlong. R N. East,
" J. D. West, free of S. *John*'s: begin South at 0, 24 at 400,
" 27, at 300 more 28, at 244 more *out* 30. Content 25526
" (that is) one rood, one pole *feré*.

Note that in this kind of ground where we say (at 0) we mean two or three pole within the land's end: for there is no certainty in taking the breadth at the very end, for the turning up the plow will get or lose egregiously. Moreover in such ground the best way is, the leader to take all the sticks anew, every time you take a breadth, which had best be not above 400 or 500, especially by the foot-chain, at 16 or 17 pole, as easiest for account, unless the measure or decrease of the land requires otherwise.

CHAP. IX.

Of hilly-grounds.

IF a ground have the bottome and top-lines both level, and both sides rising alike, it is to be accounted but as a declining levell, and to be measured as a level ground.

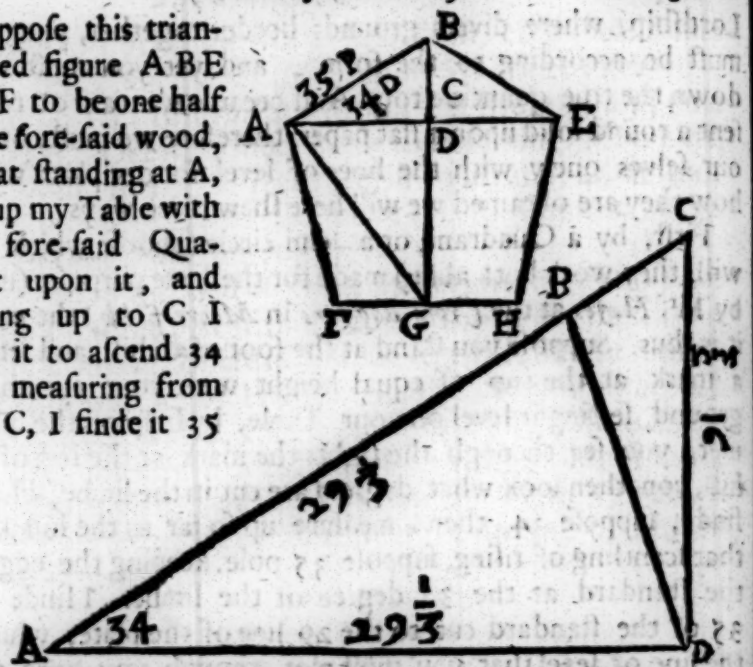
But suppose a ground be level at one end, and both sides, and rising in the middle, and a hill rising along up the middle, as the Lady *Farmer*'s *Washrods-wood* in *Westoning*-Parish in *Bedfordshire:* or perhaps two hills rising, one towards one side, and another towards the other, and a levell run through between them; this is far more troublesome. For if you shall begin to measure and plot your two levell side-lines, and levell end-line first, and then measure your line at the other end, it will not lie between the two side lines by a great deal. Again, if you should shove out those side-lines, that you might lay that line at the length you measured it, you would drive the hedges into the adjacent grounds, and make them too little: as shall apear. But if you are to give a fair plot of a Lord-

Lordſhip, where divers grounds border together, your plot muſt be according to the form, and yet you muſt write down the true quantitie too. And becauſe we cannot repreſent a round ſolid upon a flat paper, therefore we muſt content our ſelves onely with the lines of level for our plot: which how they are obtained we will here ſhew three ways.

Firſt, by a Quadrant, or a ſemi-circle (chooſe which you will, they work both alike) made for the ſame purpoſe: (made by Mr. *Hayes* at the *Croſs-daggers* in *Moore-fields*) the uſe of it is thus. Suppoſe you ſtand at the foot of an hill, and ſetting a mark at the top of equal height with your eye to the ground, ſetting it level on your Table, by help of the plummet, you ſee through the ſights the mark at the top of the hill, you then look what degrees are cut in the limbe, which I finde, ſuppoſe 34, then I meaſure up ſo far as the hill keeps that ſcantling of riſing, ſuppoſe 35 pole, keeping the edge of the ſtandard at the 34 degree of the limbe. I finde that 35 of the ſtandard cut to the 29 line of the plate, which is the line of level that you muſt plot, though you have gone 35: all theſe I enter into my field-book. If the hill ſtill riſe, you muſt ſet again, and as it riſes, or falls, ſo you muſt alter: ſo far as it goes level, plot it as level; and what is hilly plot it as hilly. And what is here ſaid of going up, the ſame underſtand of going down.

But never go about to caſt up by this plot, though you have ſhut it never ſo true: as indeed in ſuch a caſe it is very tickliſh; therefore in this caſe we may well allow to miſs a pole or two in ſhutting, and yet account it well done too. But for caſting it up, this way that it is meaſured helps not to the finding the true quantitie, though the extending that laſt line doth come near to the truth, and may indifferently ſerve in caſe of letting, becauſe it always is a little under the length, as will eaſily appear in this diagram.

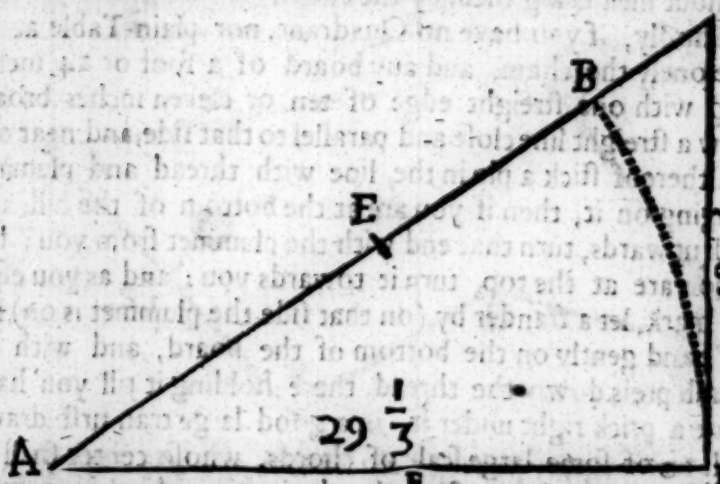
Suppoſe this triangulated figure A B E H G F to be one half of the fore-ſaid wood, & that ſtanding at A, I ſet up my Table with the fore-ſaid Quadrant upon it, and looking up to C I finde it to aſcend 34 degr. meaſuring from A to C, I finde it 35



poſe: ſo then keeping the ſtandard at 34 of the limbe, 35 of the ſtandard gives you both 29 $\frac{1}{3}$ for your line of level, and 19 $\frac{2}{3}$ both upon the plate at once: *viz.* A D, the line of level, and C D the perpendicular; now if you add A D, and F G, together, being right angled at G D, and multiply the half thereof by D G, you ſhall fall ſo much too ſhort, by how much the multiplication by your D G, is ſhorter then it ought to be: for in as much as F H is level, and A D ſo much riſing as D C, it muſt needs follow, that G D riſeth up to C, as appears in the other figure. For it is the Hypotenuſe to G D, a line of level, and C D a perpendicular. For ſuppoſe G D and A C in the firſt figure to be both of one length, *viz.* 35 pole a piece, and G D in the firſt figure, and A D in the ſecond be all one, as if it were the line of level; but now if you lift up A D to A B, it will not reach to C, by the diſtance of B C in the ſecond, *viz.* 5 $\frac{2}{3}$; for if you ſubtract 29 $\frac{1}{3}$ out of 35 which is A B, there reſts B C, *viz.* 5 $\frac{2}{3}$: ſo that your triangle G A D in the firſt is leſs then the triangle A D C in the ſecond,

cond, by the triangle B C D in the ſecond, which comes to near 50 pole in that triangle. But hereby you ſee, that having this level plot, and your degrees aſcending, and lengths of your lines aſcended, you may finde out your perpendiculars: and by them, and the lengths of ſuch lines as ſhoot upon them, I mean, having the height at both ends, which you ſhall always take in going round, you may both finde the aſcents of thoſe croſs lines, and lengths of them alſo by your Quadrant, without meaſuring them by the chain. For this inſtrument having the angle of aſcent (whoſe complement is the angle of deſcent) and any one of the three ſides of a rectangle triangle doth give you both the other, always making the ſtandard the Hypotenuſe, and having any two of the ſides, it gives both the angles of aſcent, and deſcent.

Secondly, To work this by the limbe of any common Quadrant. Take the angle of aſcent as before, and meaſure the aſcending line A C, let the angle be 34, and the line 35, as before; and I deſire firſt the line of level A D: ſecondly, the perpendicular D C. Firſt, draw the line A C upon the centre A, making the angle A 34 degr. which is done after this manner.



Take 60 from the ſcale of chords, with that wideneſs ſet one foot in A, and with he o thertran the arch D B, and take off

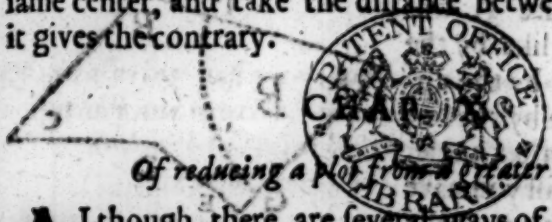
34 d. from the ſame ſcale of chords, and ſet it in the ſaid tran from B to D, then draw the line A D, then take 17 ½ being the half of 35, and ſet from A to E, and again from E to D, making pricks in E and D. Keep one foot of the compaſſes at E, and with the ſame wideneſs make a prick at D, and another at C ſo ſhall A D be your line of level, and D C the perpendicular; both which if you take with your compaſſes, and apply to your ſcale of equal parts, you ſhall finde A D the line of level, to be 29 ½, and C D 19 ½, as afore.

If an hill run ſtreight along a ground, if by one ſide it will be a mere declining level, if through the middle it will be two declining levels, and that line ſo running along the top will be a line of level, and equal to the line of level under it, therefore if you add both ends together, as you meaſured them by the chain, and multiply half of them by the length of that line you have the content, if it be of equal height at both ends. But if it be unequal at both ends, though it be a declining level, and have more then three angles, your beſt way is, to part it in ſeverall triangles, whoſe Hypotenuſes and perpendiculars you may finde by either of the two former ways, without meaſuring them by the chain.

Thirdly, if you have no Quadrant, nor plain-Table at all ſave onely the chain, and any board of a foot or 14 inches long with one ſtreight edge of ten or eleven inches broad; draw a ſtreight line cloſe and parallel to that ſide, and near one end thereof ſtick a pin in the line with thread and plummet hanging on it; then if you are at the bottom of the hill, and look upwards, turn that end with the plummet from you; but if you are at the top, turn it towards you; and as you eſpie the mark, let a ſtander by (on that ſide the plummet is on) lay his hand gently on the bottom of the board, and with his thumb preſs down the thread, there holding it till you have made a prick right under it, in a good large tran firſt drawn with 60 of ſome large ſcale of chords, whoſe center ſhall be the hole where the pin ſticketh, then take with your compaſſes the diſtance between the ſaid prick in the ſaid tran, and the

begin-

beginning of the ſaid tran, and apply it to the ſame ſcale of chords you drew the tran by, it gives the complement of the angle aſcending, *viz.* the degrees of the angle deſcending. But if you are at the top, and look downward, it gives the complement of the top-angle, and degrees of the bottom aſcending. But if you will but erect a perpendicular upon the ſame center, and take the diſtance between the prick and it, it gives the contrary.



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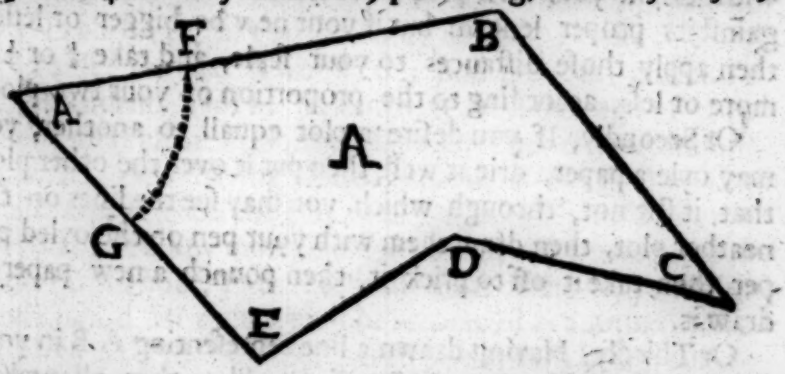
Of reducing a plot from a greater to a leſſer.

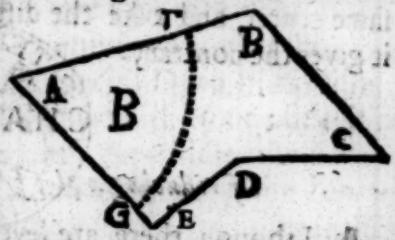
ALthough there are ſeveral ways of performing this, as likewiſe of a leſſer to a greater (whereof there is great uſe in turning ſtatute-meaſure into the eighteen-foot pole, &c.) we will lay down onely this one generall rule.

Firſt, begining at any one angle, as at A, and ſo go round in order from angle to line, and from line to angle: Suppoſe the plot (A) to make another, *viz.* B but a quarter ſo big: yet like it both in form and content, onely it is drawn with a ſcale of half that bigneſs; for $\frac{1}{2}$ the bigneſs gives but $\frac{1}{4}$, becauſe $\frac{1}{2}$ of $\frac{1}{2}$ is but $\frac{1}{4}$ and ſo $\frac{1}{3}$ make but $\frac{1}{9}$ part ſo big, becauſe $\frac{1}{3}$ of $\frac{1}{3}$ is $\frac{1}{9}$.



Firſt draw the line A B of the figure B, repreſenting the line A B of the figure A, regard not though it be as long as it or longer: at the end thereof make a prick for a center, and write,

or ſuppoſe (A) to be there written, then open your compaſſes to any wideneſs, as to F in the figure (A) and tran F G; with the ſame wideneſs do the like in the figure B, take F G in the figure A, and ſet it in the figure B, then take either ½ the line A B of the figure A, and ſet it the ſame way in the line A B in the figure B: or elſe take half the length thereof from the ſame ſcale the figure A was drawn by; do the like by the angle B, as you did by the angle A, and likewiſe by the line BC, and ſo angle after angle, and line after line, till you have done. And thus may you make a plot bigger or leſſer, as you pleaſe, onely by changing the ſcale, yet the *area*, or content, will be the ſame, as before. But if the borders of your plot be very crooked, it wil be needfull to draw ſtreight lines, either within or without both the plots, like ſtation-lines in both the old plot and new, and to take the crooks from thoſe, juſt as you did in the field, if you will have it equall in bigneſs to the other, and that your ſtreight lines be of like length in both; then ſet the ſame wideneſs in your new plot from your ſtation-lines, each againſt its proper length: but if your new be bigger or leſſer, then apply thoſe diſtances to your ſcale, and take ½ or ⅓ or more or leſs, according to the proportion of your two plots.



Or Secondly, If you deſire a plot equall to another, you may oyle a paper, drie it well, then put it over the other plot, that it ſtir not, through which you may ſee the lines on the neather plot, then draw them with your pen on the oyled paper, then take it off to prick it, then pounch a new paper & draw it.

Or Thirdly, Having drawn a line repreſenting A B in your new plot, take the line A B off the old, either all, or ½ or according to your deſired proportion, & ſet it on the new. Alſo take the proportion of the line (A E) and ſet one foot in (A) and tran where you think (E) will fall in your new.

Take

Take alſo the like proportion of the diſtance of (B E) and ſet in the ſaid tran, and ſo you have (E), the ſame 2 diſtances will ſet out (D) alſo (D and B) will ſet out (C) and ſo you have all your angles, then draw their lines, and you have your plot deſired.

CHAP. XI.

Of meaſuring paſture-ground by the chain onely, and that as ſpeedily and exactly, as with any inſtrument whatſoever, and with leſs help though in miſty weather, & to plot, ſhut, and prove, the plot thereby alſo.

ABout the midſt of one of your longeſt ſtation-lines, and ſome known length in the ſame (as at X in the firſt or third cloſe, chap. 3[d] pag. 22) ſet up a mark, and mark it in your book, both with its proper length & letter, then having meaſured round about the ground on the inſide, or at leaſt all but the laſt ſide: if you have more then three angles, in ſtead of meaſuring it from angle to angle: *viz.* in the firſt cloſe, from A to C, or from B to D, you ſhall meaſure from C to X, and from X to D, ſo making a triangle the more then otherwiſe; which two ſubtendents will eaſilie be run whileſt you can ſet up the Table once, ſo you ſhall need leſs help by one to carry your Table, for that is wholly one bodies work; and theſe two ſubtendents muſt be ſet down at the latter end of your notes of that cloſe in your field-book. Then if you meaſure the laſt ſide A D having plotted the reſt, if that A D on the ground, and A D on the plot agree, all is right, neither ever need you divide any more lines then one in the whole ground or cloſe throughout, ſo that at leaſt none of the ſtation-lines ſtrike outward, for then it muſt be accounted as another cloſe, ſo much of it till the laſt line that ſtrook inward being continued ſtreight out do meet with the other plot again. See more chap. third.

Now to plot ſuch a ground meaſured by the chain onely, ſuppoſe it be the ſaid firſt cloſe, (*chap third*) firſt I draw the line

line A X B, making a mark at X, and another at B: ſecondly you muſt either take the ſubtendent X C, ſetting one foot of the compaſſes in X, & tranning where you think C will fall; or elſe take the ſtation-line B C with your compaſſes and ſet one foot in B tran at C and then take the other of theſe two laſt lines, *viz.* X C. ſetting one foot on its proper mark X, and with the other make a prick in the ſaid tran, and ſo have you placed C in his right place, then draw the line B C, next take C D with your compaſſes, ſet one foot in C, and tran where you think D will fall, then take the ſubtendent D X, ſet one foot in X and make a prick in the ſaid tran, and that ſets out D, then draw the line C D, and becauſe D is your laſt ſtation, and that A and D are both ſet out already; therefore, draw alſo the line A D, now if A D on the plot and A D in your book agree, then all is right, elſe not. So that in this kinde of plotting there are onely theſe three poſitures. Firſt, draw a ſtation-line; ſecondly, tran with a ſubtendent; thirdly, prick with the next ſtation line.

Nevertheleſs in great larg plots, it will be needfull to uſe a good larg pair of compaſſes, becauſe you muſt take the whole length of your lines with them. In which caſe a pair of beam-compaſſes, with a beam of deal, willow, or ſallow, or ſome ſuch ſoft wood, is beſt of all, of 17 or 18 inches long, with a piece of an awl-point near one end, and a ſliding button to be moved pretty and ſtifly up and down, and to be ſtayed with a ſcrew pin, or wedge at any diſtance, with an other ſhort point in the end thereof.

Now we will ſhew you how to continue your plot out of one ground into another, that ſo you may lay all the grounds of a Lordſhip together in one entire plot by the chain onely, and that we will do by ſeverall rules; for the underſtanding thereof we will refer you to the plot in the latter end of the third chapter, as alſo in the end of the book. The knowledge whereof conſiſteth in four rules in the obtaining the firſt ſtation-line in the cloſe which you go unto. As for example.

Firſt, Suppoſe I would go out of the firſt cloſe at A, and would

would plot the ſtation-line A G: now becauſe in plotting theſe kinds of grounds you muſt always reduce all into triangles, therefore ſtanding at A you may meaſure two chains length in the line A F, or A G, likewiſe two chains back-ward from A towards B, in the line A B in the firſt cloſe; then meaſure the diſtance between thoſe two lengths, and plot them after this manner: Firſt, your beſt way is (though you have meaſured but two chains length a piece, yet) in ſtead of two, take the double, if the ſtation-lines be long, you may triple that diſtance, ſetting one foot in A, and extending the other towards B; there make a prick in that line, and tran from thence with that wideneſs where you think the line A F, or A G will fall: then look what the diſtance was between the two lines at the end of your two chains a piece; if doubled before, then double again that diſtance upon your ſcale, and ſet it in the tran from the line A B in the firſt cloſe to the line A F in the ſecond, and draw the line A F G through that prick *ad infinitum*. Thus have you got a line in the ſecond cloſe, by help of a part of the line A B, which in this kinde you muſt always take, *viz.* that ſtation-line, whereof the whole or part belongs to both the cloſes. But becauſe in this caſe you muſt always mete through the hedge, from the two chains of one cloſe to the two chains of the other: therefore to avoid the trouble of cutting a hole through the hedge, if there be ever a gap, gate, or ſtile near unto thoſe lengths, you may take more or leſs of thoſe two lines as you pleaſe: now becauſe here is a gap at two chains and an half from A, in the line A B, you may meaſure two chains and an half of either of them, or two and an half in that, and three in the other, as you pleaſe; and meaſure the diſtance upon the ground between thoſe two pricks: then you may double all three diſtances upon your ſcale, as afore, and ſet out the proper diſtances between thoſe two pricks, as afore, and then draw your line A G upon your plot in the ſecond cloſe.

But, Thirdly, becauſe we have meaſured the diſtance between A and X in the firſt line, which is one ſide of the trian-

gle of that ſecond cloſe, and likewiſe have meaſured from A to G on the ſecond ſide, and have a gap alſo at X: therefore if you meaſure G X, you will have all the ſides of that great triangle, which you may uſe as afore-ſaid: Firſt, you have the line A X already placed. Secondly. take the length of A G with your compaſſes upon your ſcale, and with that wideneſs, ſet one foot in A, and tran where you think G will fall. Do likewiſe with the line G X, taken alſo upon your ſcale, ſet one foot at X, and the other is the foreſaid tran, and there is your center G.

And after the ſame manner may you go out of that cloſe, into the great cloſe from G, by help of the line A G. Now having the line A F, or A G, you may eaſily ſet out the triangle A F E, as you did A X G. Likewiſe you ſet out the triangle that is between the the line X G and the hedge, between the two cloſes onely by the diſtance of G to the entrance of the great cloſe.

A ſecond way of going out of one cloſe into another is, when I have a ſtation near the middle of a ſtation-line, and that there I would go into another cloſe. For example:

Suppoſe I would go out of the great cloſe into the firſt cloſe, right againſt the ſtation-line B C in the firſt from L in the ſtation-line of K; then when you come right againſt B C, the ſtation line, lengthen that line B C back-ward into the great cloſe from L to M two chains length; meaſure alſo two chains lengths in the ſtation-line L K; and meaſure two chains lengths from L to I back again; and meaſure the diſtance between two chains of the one, and two chains of the other, and that gives you the quantitie of the angle K B C. Then from the line L K; you may take from your ſcale four chains length, and you may tran from the line K L, towards the line L C, or B C, with one foot ſet in L, and double the diſtance of the two pricks in the other cloſe, and take that with your compaſſes, and ſet from the line L K, to the L C, and where it falls draw the line L C *ad infinitum*. After the ſame manner might you have drawn a line by the South-ſide of the hedge

by

by B C or L C. Alſo ſo might you at X in the firſt cloſe have gone either into the great cloſe, or into the little cloſe, by drawing a ſtation-line on which ſide of the hedge you will.

A third way is by continuation of ſuch a ſtation-line as ſhoots upon the corner of a cloſe; and thus ſuppoſe you would go out of the great cloſe into the little cloſe at K, if you had but continued your line L K to A, and this is the eaſieſt way of all.

A fourth way, If on the Weſt-ſide of the hedge A K there were a ſpinny wood of two or three poſe broad all along by the ſides thereof, and that you deſire to go out of the firſt cloſe into that little cloſe, but there is no gap, ſave onely you can ſtrike a ſquire-line from the ſtation-line A B, at either end of A & K; then may you both at A and at X erect a perpendicular into the firſt cloſe ward; and then may you continue thoſe two perpendiculars, ſo far as you ſhall need them, till you are free from the ſpinny, and may draw a line from one to the other by the ſpinny ſide, and truly plotting out either perpendicular from the laſt ſtation-line.

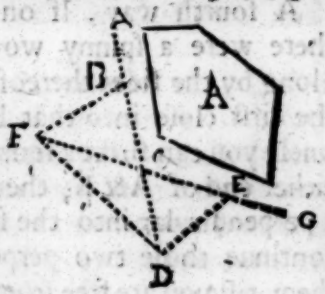
CHAP. XII.

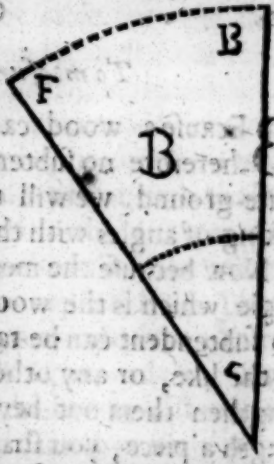
To meaſure a wood by the chain onely.

BEcauſe a wood cannot be meaſured on the inſide; and therefore no ſubtendents can be taken, as they may in paſture-ground, we will therefore endeavour how to do it by taking of angles with the chain.

Now becauſe the meeting of the ſtation-lines gives but one angle, which is the wood corner, or at leaſt ſo near to it, that no ſubtendent can be taken from any part of one of thoſe lines to the like, or any other part of the other, yet if you croſs or lengthen them out beyond their meeting one or two chains length a piece, you ſhall then have three angles more, whereof the oppoſite angle to the wood angle will be the ſame with the wood angle, and either of the other will be the complement of it to 180 degrees; ſo that if you can but take one ſhort

line in any of thoſe three angles, you are well enough: as ſuppoſe A to be a wood, and at the angle C, I had two ſtation-lines met, *viz.* A C, and C G, I continue A C forward to D one chaines length, or elſe ſet C G backwards to F a chains length, and likewiſe ſet back A C to B one chain of 100 links: now ſuppoſe I find F B or D E to be 60. now for that C B and C F are each of them 100 and F B 60. I firſt plot them, firſt ſtriking a line, then I take 100 from ſome ſcale of equal parts, as C B in the figure B. And becauſe C B and C F are equall, therefore I ſet one foot in C, and tran F B, alſo from B to F I ſet 60 of the ſame equall parts, then draw the line F C through C, and it gives the ſtation-line C G; Or more eaſilie, if you draw out the line A C unto D, and make C D and C E 100. a piece, finding D E to be 60 then may you take 100 of any ſcale of equal parts & tran D E then ſet 60 of the ſame parts in the ſaid tran from D toward E, make there a prick & draw the line C G through E. But if by reaſon of impediments you can neither meaſure D E nor F B at 100 a piece, you may tran C B 200, and F C 100, or either of them what you will, ſo that you plot them accordingly; as if C E be 130, C D 100 and D E 50; then firſt ſet out C D 100 in the line C D, ſecondly take C E 130, ſet one foot in C and tran with the other, and thirdly take D E 50, ſet one foot in D, and with the other make a prick in the tran and draw the line from C through E as afore. Now if through impediments by none of the foreſaid ways you can meaſure neither of the foreſaid angles, then ſee what you can do to the





the angle F C D, or the angle oppoſite to the angle of the wood: for this therefore you muſt both lengthen A C to D forward, & C G to F backward, each of them 100 or more from C; then meaſure the diſtance D F, and apply it to your ſcale of equal parts, and what it gives ſet down in your note-book, as likewiſe you muſt do all the other lengths. Then ſuppoſing C D, and C F to be 100 a piece, I take 100 and ſet one foot in C, and tran from E, then ſuppoſe I had found D F 160. I take therefore 160, and ſet from D in the ſaid tran, and it reacheth to F; therefore draw F *ad infinitum*, and it gives the next ſtation-line C G.

But in all this that hitherto we have ſpoken of meaſuring by the chain onely, we would have you to undetſtand, that we have onely ſpoken ſpoken of meaſuring and plotting of the ſtation-lines: for as for meaſuring, caſting up, and plotting of the out-ſides, that is the ſame as before, ſerving as well to this as to the Table.

And as for meaſuring hilly-ground, we have ſhewed before in *chap.* 9, that alſo may be meaſured by the chain alone, ſave onely any ſorry board with one ſtreight edge; & it matters not greatly whether it have a ſtreight edge or no. If in meaſuring the out-ſides you go upon a ſtation-line, as in the line A F G of the ſecond cloſe, (*chap.* 3) from which you deſire to ſtrike a perpendicular into an angle: Firſt, ghueſs at the place, ſo near as you can, where it will fall; there ſet one of your counting-ſticks, ſet another 80 links backwards, directly in the ſtation-line; another at 60 from the firſt ſtick into the angle; then let one hold one end of the chain at the ſtick that was ſet backward, and the other at the ſtick ſet in the angle-line; if they two meet juſt at the chains end, (I mean *Gunther*'s chain of 100 links) then is it a true perpendicular into the angle; if it fall ſhort, you are not far enough, if gone, then you are too far.

If a ground be very large or buſhy, you may meaſure it on the out-ſide like a wood; or meaſuring a chains length or two of each ſtation-line, and their ſubtendent on the inſide from the angle.

Thus have we ſhewed you how to meaſure all manner of ground by the chain onely, for which I expect as much thanks at the inſtrument-makers hands, as *Culpepper* at the Colledge of Phyſitians. And indeed I was determined to have publiſhed it above fourty years agone, had not Mr. *Allen* and Mr. *Thomſon* diſſwaded me from it, upon this reaſon, That if ignorant people ſee the moſt famous Artiſts go ſo to work, they will be ready to judge, that he that goes with a plain pair of poles, and a ſquare board, to ſet out a ſquare withall, is a better workman then he. And indeed, I cannot deny but that they judge according to their tools which they ſee, rather then according to their skill they ſee not.

Whereupon I have forborn till now, conſidering I am even dropping into my grave, and conſidering that my Saviour would not ceaſe caſting out devils, becauſe he was thought to do it through *Beelzebub*; no more will I longer forbear this, it being ſo lawfull, and honeſt, and beneficiall to a Commonwealth. And truly had I regarded mens ſayings I muſt have given over ſurveying long ago, or elſe to give over profeſſion, for that I was judged (by no ſmall fools) to work by the devil, for that I could tell a diſtance before I meaſured it.

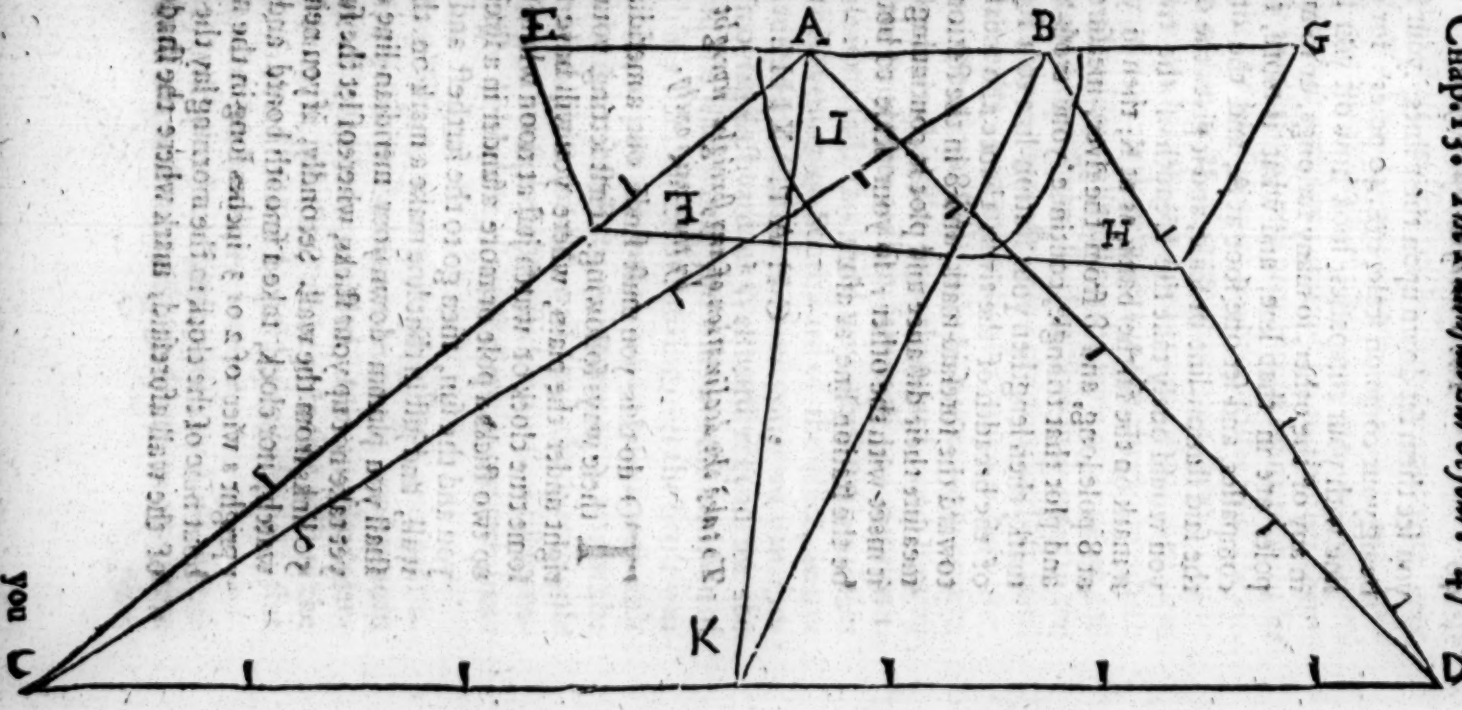
CHAP. XIII.

Of taking diſtances by the chain onely.

ALthough we have ſhown the meaſuring of all manner of land by the chain, yet ſince we are ſpeaking of the uſe of it, I hope you will not think your time ill-ſpent to read a leſſon or two more that will be effected by it.

Let there be two forts C and D of a good diſtance aſunder, beyond a river a mile or two broad; to tell the juſt diſtance how far they are aſunder, how far each is from A, and each from B, and the breadth of the river: Firſt, I draw the line A B 40 pole, a tenth part (at leaſt) of the greateſt diſtance; let it run parallel, but ſtreight, by the river, 9 or 10 pole off; then from A I ſet out both backward from A to E directly backward in the ſtation-line ſix pole, and ſix from A to F in A C line

line, then E and F are four pole asunder. Also I measure from B to G, and from B to H 6 a piece, and 6 between them also; and from A toward B and D 6 piece, and they are 4 ¼ asunder, and from B toward A and C 6 apiece, they will be 3 ½ asunder: but it is best to draw your station-line with a very small scale, but set out your angles with a very great one: then draw A D and B D, till they meet at D, likewise A C and B C, till they meet at C, and a right line from C to D, for the distance of the two forts: and another from B to K for the breadth of the river, so shall you finde all your desired distances of



you ſee them ſet down upon their lines; your ſtation-line A B, being your common ſcale, *viz.* 40 poles: for if you take that line with your compaſſes, look how oft you finde that length in any of the other, ſo many furlongs, or ſo many times fourty poles are in that line, and what is more, take it with your compaſſes, and ſet one foot at A, and the other forward in the ſaid ſtation-line or ſcale, and it gives the odd poles. But if you would onely take the breadth of the river K L, obſerve a mark on the farther bank, as at K; then in your ſtation-line at 8 pole long, and 8 from the river, meaſure their diſtance, and plot that triangle, continue your croſs-line toward your mark; then lengthen your ſtation-line to a fourth or fifth part of the breadth of the river; thence alſo meaſure 8 pole right toward the foreſaid mark, and 8 in the ſtation-line backward; meaſure their diſtance and plot it, continuing the mark-line till it meet with the other: ſo your ſcale to both the other will be the ſtation-line, as afore.

CHAP. XIIII.

To take the declination of any ſtreight upright wall for Dialling by the chain onely.

TO do this you muſt finde out a meridian-line by any of theſe ways following. Firſt ſetting your back to the wall right under the plain, where you will have the dial, look by ſome true clock or watch juſt at noon where the ſun is, and ſet up two ſticks a pole or more aſunder in a ſtreight line between you and the ſun, then go to the furtheſt and look back to the wall, and juſt in that line make a mark on the wall: for there ſhall you plumm down your meridian-line of your dial. But yet take not up your ſticks, whereof let the furtheſt of them be 50 links from the wall. Secondly, if you neither have help of watch, nor clock, take a ſmooth board and lay it level, ſtick upright a wier of 2 or 3 inches long in the midſt of it, and about nine of the clock in the morning lay the board at the foot of the wall aforeſaid, mark where the ſhadow of the top of the

the wier falleth, there make a prick: then take out your wier, and ſet one foot of your compaſſes in that center, and open the other to the former prick, and there draw a circle, and then ſet up your wier upright as it ſtood before, neither deeper nor ſhallower then before; you may apply a ſquire to it, to ſee it ſtand upright, or meaſure with your compaſſes from the circle to the top of the wier, if it be alike all 4 ways. If it be right, ſet up two ſticks right in a line between it and the Sun as afore. Then again about three a clock in the afternoon watch where the Suns ſhaddow falls juſt on the ſame circle again, and then ſet up two other ſticks, ſo that they may meet in the ſame centre: divide the ſpace between the two furtheſt ſticks into two equall parts, and mark that for your meridian-line. But leſt the Sun ſhould not ſhine when it comes to that circle, you may make ſeverall circles upon the board, and ſtick up marks where the Sun comes at them forenoon and afternoon.

If both theſe ways fail, this third way is better then either of them. In the evening go Southward of the place, where you would haue your diall, three or four pole, turn your face Northward, moving Eaſtward or Weſtward till you ſee the North-pole and the place where you will have the meridian of your diall both in a line, which by looking over the houſe you may the better do, if you get one to hold a pole aſlope with a line tyed to the end thereof and a plummet to it. If now the line, the meridian-place on the wall, and the North-pole are all in a line, you are right, there ſtick up a ſtick till morning, another right behinde it; for juſt there is your meridian-line.

Now to know the pole you may eaſily ghueſs at it near enough, for it is a point in the heavens in a right line between the hinder horſe of *Charles-wain* called *Alliot* and the polar-ſtar, ſo far off from the pole-ſtar, as the pole-ſtar is from the next ſtar to it: ſo that if *Alliot* be juſt beyond the polar ſtar then is the polar-ſtar full North, *& è contra.*

A fourth way is this; in ſome plain place near hand where you may ſee both ways ſet a mark, go South two or three

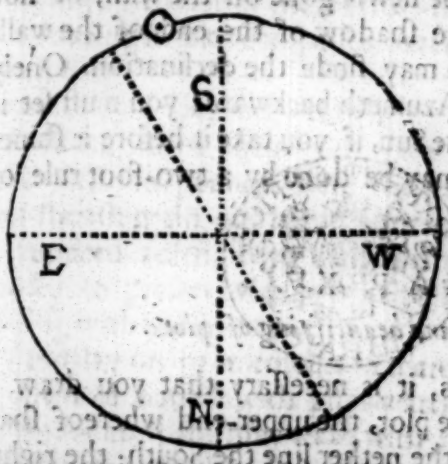
pole, then move Eaſtward or Weſtward till you ſee the pole-ſtar right beyond the firſt ſtaff, there ſet another, or rather pitch two good ſtones, like grave ſtones in Church-yards: for ſo they will not onely ſerve for this buſineſs, but alſo give the hour of the night to a minute by knowing the right aſcention of the Sun and ſtars.

The uſe we make of it here is double: firſt it helps us to ſet out the meridian-line every where near hand; for if ſtanding here at the North ſtone you ſee the Sun right over a ſtick or pole holden at the South, you run preſently & ſet your back againſt the wall where you would have your diall, and ſet up two ſticks between the Sun and you, you have a meridian-line deſired.

Now having gotten this meridian-line: to finde the acute angle that this meridian makes with the wall; firſt, meaſure with your chain one chain, or half a chain in this meridian, and as much by the wall-ſide, and their diſtance for a third ſide, and plot it; then finde the quantitie of the angle of interſection of the meridian and wall-line by the ſcale of chords, the complement thereof is the declination of the wall. Suppoſe the line A B to be a meridian-line, and A C to be the wall-line, in either of which I meaſure from A to C, and from A to B 50 links, and I finde the diſtance of C B to be 24½, this I plot as afore is ſhown. Then to finde how many degrees the angle C A B makes, take 60 from ſome ſcale of chords, and ſet one foot in A, and tran D E: then take D E with your compaſſes, and apply to your ſcale of chords, and it gives the angle of the wall, and meridian D A E, or C A B, which is all one, to be 30 degrees, and the complement thereof 60 is the declination of the wall; which if it were taken in the morning, it is a South-weſt diall declining Weſt-ward 60 degrees: (for always the diſtance of the wall-

line

line to the East or West-line is the declination of the wall:) if the Sun shine on it at noon, it is a South diall; if it shine longer on it in the after-noon, then in the fore-noon, it is a South-west, *& è contra.*



Having a meridian in some open and plain place, to finde the Azumeth, set up a stick at the South-end of your meridian-line, measure back in it 50 links there make your centre A, thence measure 50 forward in the Sun-line; measure the distance of those two fifties; and plot it, then take 60 off your scale of chords, and do as in the last rule.

Having the Azumeth, to finde the angle of the wall and Sun by help of the last figure.

Sometime you are in such a place where you cannot set out a meridian-line, yet you may always set out an Azumeth, or Sun-line, which elswhere I call the angle of the wall and Sun. Now finding your Azumeth, as in the last rule, come presently from thence, not staying to cast it up or plot it; but presently measure 50 by the wall, and 50 in the Sun-line, and their distance, and then plot both the triangles, and finde the degrees of both angles at the centre, as afore; so have you both the Suns Azumeth, and the angle of the wall and Sun. Then making a circle with two cross diameters, first set out your Azumeth from the South; if it was taken in the morning, then on the East, if in the after-noon, on the West. Then always reckon backward the angle of the wall and Sun in the course of the Sun; and from thence draw a line through the centre representing the wall-line, (as in the last diagram) the distance

tween that and the East and West line in the circle is the declination of the wall desired.

And although the Sun be newly gone off the wall, or not yet come on, by help of the shadow of the end of the wall, and these former helps you may finde the declination. Onely in stead of setting your Azumeth backward, you must set it forward in the course of the Sun, if you take it before it shines on the wall. And all this may be done by a two-foot rule or yard, or a boyes cat-stick.

CHAP. XV.

Of colouring and beautifying of plots.

IN beautifying of plots, it is necessary that you draw a square round about the plot, the upper-end whereof shall represent the North-side, the nether line the South; the right-side line the East: but you must help your self to these by taking a meridian-line first in the field, and drawing a meridian-line through the first plot.

Secondly, Examine your former plot, how many chains or poles your plot reacheth from North to South, and from East to West, and thereby make choise of such a scale, that you may lay the whole Lordship within the said square, according to the Northing, and Southing, and distance. Or else you may draw your plot, first, by what scale you will, and then draw the square afterward.

Thirdly, Fill the out-borders between the square and the demeans, at least such as border next to the demeans, with the bordering hedges, and names or owners names of the grounds.

Fourthly, Whatsoever you write, write it from West to East: unless it be the proper name of some river, or high-way, or such like. For if the North be upward, the West will be on the left hand.

Fifthly, Describe all houses, ways, rivers, Churches, windmills, arbours, great lone-trees, gates, stiles, &c. that fall within your plot, as also the Lordship-house, with other edifi-

ces

ces in a corner by it ſelf, and the Lords coat in another corner: the houſe being drawn in proſpective.

Sixthly, Deſcribe at the bottom the ſcale that you drew it by, adorning it with compaſſes, ovalls, ſquares, and compartiments, &c.

Seventhly, Having drawn all your ſeverall grounds, and diſtinguiſhed them with their hedges, it will not be amiſs firſt to pounce over the paper or parchment with ſome ſtaniſh grain, and burnt Allome, and a double quantitie of pounced roſen, both finely ſearced, and lightly pumiced, thereby to preſerve the paper or parchment from through-piercing with the colours.

Then lay on your colours in manner following, being firſt ground and bound with gum-water very thin and bodileſs. Arable for corn you may waſh with pale ſtraw-colour made of yellow-ocre and white-lead. For meadows take pink and verdigreaſe in a light green. Paſture in a deep green of pink, azure, and ſmalts. Fenns a deep green, as alſo heaths of yellow and indico. Trees a ſadder green of white-lead and verdigreaſe. For mud-walls and ways mix white-lead, and ruſt of iron, or with ocres brown of *Spain*; for white-ſtone take umber and white: water or glaſs may be ſhown with indico and azure, or black-lead: for ſeas, a greeniſh sky-colour of indico, azure, ſmalts, white-lead, and verdigreaſe.

CHAP. XVI.

To meaſure all manner of ground by the Pandiron, or any other graduated Inſtrument.

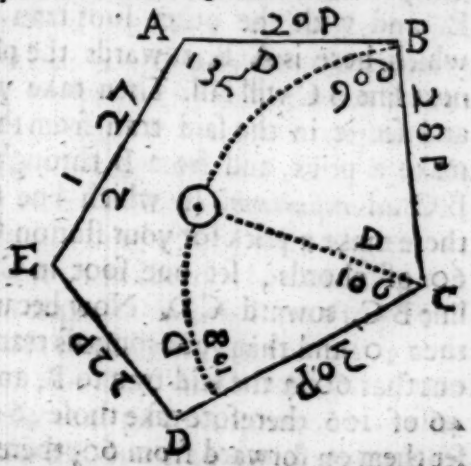
THe Pandoron is an Inſtrument compounded of, Firſt, an ordinary foot, with three legs for a plain Table. Secondly, a Table and folding-rulers like it, ſave that it is a true ſquare. Thirdly, the box and needle. Fourthly, it hath on one corner a centre, in which is a ſcrew-pin, on which a moveable ruler with ſights turneth. Fifthly, in the two out-ſides furtheſt from the centre is drawn the Quadrate for terreſtrial altitudes and

diſtances. Sixthly, next to it is the limbe of the Quadrant, both for celeſtial and terreſtrial altitudes and diſtances, whether upright, flat, or aſlope. Seventhly, *Gunther's* Quadrant for your own latitude for houres both of night and day, and Azumeths, and divers other problems. Eighthly, *Fale's* Quadrant for Planetary houres. Ninthly, a circle and ſcale for finding the declination of a plain. Tenthly, a neck of 14 or 15 inches long, to put on the top of the ſtaff, the Table being taken off, with a pin on the ſide to hang the Table on, to take all manner of altitudes and diſtances aſlope. Eleventhly, a beam of 6 or 7 foot long about two inches ſquare of deal, and a trough on the top, gouged all along half an inch deep, to fill with water for a water-level having a ſight at each end, having a lath croſſing the beam in the middle above and below 6 foot long, faſtened with ſcrew-pins and brackets above and below, with an hole in the bottom of the middle of the beam, in ſtead of a ſocket to ſtand on top of the three-foot ſtaff. So that there is nothing that all or any obſerving Inſtruments can do, but this doth it. By this you meaſure land as by the plain-Table, then if the weather be moiſt, or in hilly ground, you may uncover the Table, and work by the Quadrant, whereby you may ſave the charge of hill-ground ſights, which are as coſtly as all the reſt of the Inſtruments. Beſides which if you know how to work by the Quadrant, you cannot be ignorant of working by the Theodelete or ſemicircles; the difference being onely this, that they take onely at once, which if it be above 90 degrees, by the Quadrant you firſt take ſome part of it, and then the reſt of it afterward, yet all at the ſame ſtation, and then plot it by your ſcale of chords. Indeed by the Circumferentor you take all the angles by obſerving the cutting of the South-end of the needle, and then either plot the angles by a protractor, and the lines by a ſcale of equal parts, or elſe you may plot the angles either by your ſcale of chords, or by the Circumferentor it ſelf both which I hold better ways then the firſt. So that there being nothing deſirable in an obſerving inſtrument but this giveth it, it ſo

pleaſed

pleaſed Mr. *Hender Roberts*, (the Lord *Roberts* youngeſt ſon, a Gentleman every way fitted with a genius for the Mathematicks, whom I cannot name without honour,) who had the firſt of them to give it the name of πᾶν δῶρον, *omne donum*. So that in ſhewing the uſe of it as it is a Quadrant, we ſhall with the ſame labour ſhew the uſe of all graduated Inſtruments in meaſuring of land; and as for working by it as by the plain-Table, we refer you to the ten firſt chapters of this book. Now therefore for working by the Quadrant, (yet herein we will ſpeak of nothing but what is within the ſtation-lines, contenting our ſelves for the reſt with that which hath been ſpoken before in the uſe of the plain-Table,) all the difference conſiſts in three things: firſt, the taking of the angles: ſecondly, in keeping the field-book: thirdly, in plotting.

Firſt, For taking of the angles, you need not ſet up your Quadrant oftner then you did the plain-Table: therefore ſuppoſe this figure A B C D E to be a plot of ground to be meaſured on the inſide: I begin at A, not ſetting up the Inſtrument, but finde A B to be 20 pole, that I ſet down in my note-book, beſides the breadths from the ſtation lines, which I omit here as ſufficiently ſpoken of before. Then being come to B, there I ſet up the Quadrant, and finde it juſt 90 degrees, I ſet down B 90 degrees, ſo that all the lengths are meaſured by poles or links, and all the angles by degrees: then I meaſure B C, and finde it 28, and ſet it down: now I come to C, I lay the ſharp edge of the rule to the line of the Quadrant, where the degrees begin, and then ſcrew down the



AB. 20. *p.*
B. 90. *d.*
BC. 28. *p.*
C. 106. *d.*
CD. 36. *p.*
D. 108. *d.*
DE. 22. *p.*
E. 101. *d.*
EA. 27. $\frac{1}{2}$. *p*

the ſights for ſtirring; but turn the Quadrant till through the ſights you ſee a mark at B, (as when you were at B you ſaw at A.) Now ſeeing that mark at B ſcrew the ſocket pin, that the Quadrant turns not; but turn your ſights to D: but I cannot, for they fall beſides the board; but I have eſpied a mark at ⊙ near the middle of the ground, *viz.* a tree, I turn my ſights to that, and ſee the ſharp edge of the rule cut 60 degrees, that I keep in minde, then I lay the ſharp edge of the rule again on the beginning of degrees, and turn the Quadrant till I ſee the ſame tree again through the ſights; then ſtir not the Table, but ſtir the ſights till you ſee D through them: then looking by the edge of the ruler, I finde it cuts at 46, which added to 60 gives the whole angle C 106: and ſo of the reſt.

To plot a plot taken by graduated Inſtruments.

Now for your plotting it, firſt draw the line A B, ſet out 20 of your ſcale of equal parts upon it, then take always 60 off your ſcale of chords, ſet one foot at the end of your 20 in B, and with the other foot tran always from the laſt line, which here is A B, towards the place where you think your next line B C will fall. Then take your angle B which is 60, and ſet it in the ſaid tran from the line A B forward, there make a prick, and from B through that prick draw the line B C *ad infinitum*. In which line ſet out 28 of equal parts, there make a prick for your ſtation C. Then take again your 60 of chords, ſet one foot in C, and tran from the laſt line B C, toward C D. Now becauſe your angle C is more then 90, and that your compaſs tran at 60, therefore firſt ſet out that 60 in the ſaid tran to B, and becauſe there wants yet 46 of 106, therefore take thoſe 46 with your compaſſes, and ſet them on forward from 60, there make a prick, and draw your line C D through it, and ſo of the reſt. So that there are but theſe things: firſt, draw a ſtation-line: ſecondly, tran your angle with 60 of chords: thirdly prick out the degrees of that angle.

CHAP.

CHAP. XVII.

In meaſuring by graduated Inſtruments, to know if your plot will ſhut, or no.

Becauſe in working by graduated Inſtruments, you always plot at home, but never in the field; and that if any thing be miſtaken in the field (as oft it comes to paſs to be ſo) then will not your plot ſhut at home: therefore either you muſt look to your needle at every plantation, or elſe you muſt meaſure all the angles, which by the plain-Table you need not do: therefore with ſuch Inſtruments the needle is more needfull, then with the plain-Table; and yet the *Circumferentor* will hardly help you herein neither, though you work all by the needle, unleſs you work by taking angles by it, which is the ſlower way. Now having meaſured all the angles, if on the inſide of a ground, becauſe all the three angles of a right line triangle are equall to two right angles, or 180 degrees, and that there are ſo many triangles ſave two as are angles; therefore if you reckon ſo many angles ſave two, for each of them 180, and finde that and the quantities of all your angles to agree, there is great hope your plot will ſhut, elſe not. As if there be a triangle, they muſt all make 180; if a quadrangle, 360; if a pentangle, 540; an hexangle 720; a ſeptangle 800; an octangle 950; but if you meaſure on the out ſide, as a wood, then every outward angle is the complement to 360 of its inner angle; therefore to take all thoſe complements, is your beſt way both to prove and plot it by, and leſs labour, if you are far from your mark, and not to go to it again, it oft-times will quit your pains, leſt you are forced to ſpend perhaps an whole days-work about that you have done, or at leaſt would have done already, to prove your angles after this manner.

CHAP. XVIII.

To take terreſtrial diſtances by the plain-Table, or Pandoron, as by the Table.

WE have ſpoken of taking them by the chain onely, in *chap.* 13. between that and this there is very little difference. We will here ſuppoſe the ſame ſuppoſitions as there: *viz.* two houſes beyond a river, between which I deſire the diſtance, alſo between each of them, and each of my ſtations: the chiefeſt difference is this, that by this your beſt way is to have your ſtation-line as near the river as you can, which let be as before A B 40 pole long. Firſt ſet your Inſtrument at *A* and turn the ſights to D C, and B, and draw their lines; meaſure thence to B 40 poles, there make a prick, but lay down your 0 pole with a very ſmall ſcale, if the diſtances be long, ſo that the 40 pole be little above an inch long. Then ſet up your Inſtrument at B, laying your index on your ſtation-line of your plot turn it till through the ſights you eſpie A, then faſten your Table and one end of your ruler turning upon the center B, turn the ſights firſt to C, then to D, then draw lines, whoſe interſections with the former will give you all your diſtances deſired.

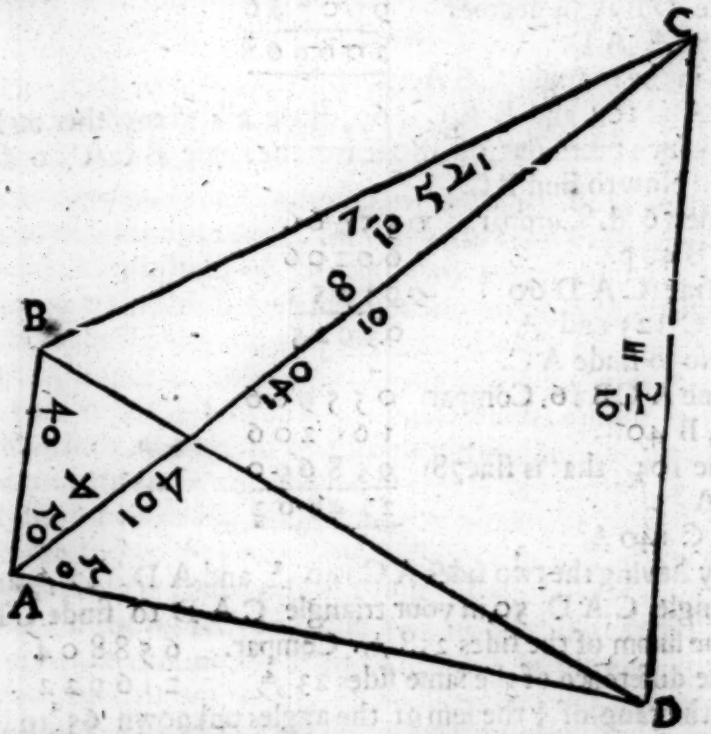
CHAP. XIX.

To do the like by the Pandoron as it is a Quadrant, or by any graduated Inſtrument.

LEt the ſame example be propounded as afore, and let your ſtation-line be A B 40 pole as near the river-ſide as you can. I ſet up the Quadrant firſt at A, where I find B A D 110 degrees, and C A D is 50 degrees: likewiſe ſet up at B, then C B A is 104, whereof C B D 50; this ſtation-line 40 and theſe angles thus plotted extend you lines till they meet, and their interſections will give you the deſired diſtances as afore: yet if you will beſtow the time and pains to caſt it

up

up by the doctrine of Triangles you may come somewhat nearer.



Firſt for the triangle B A D, ſeeing that B A D is 110 degrees, and the angle A B D 54: which make being added 164, which take out of 180, reſts the angle A D B 16 degrees.

Now in the ſame triangle having all the angle and the line A B: to finde the ſide A D.

As the ſine A D B 16. Comparithmes	055966
is to A B 40.	160206
So ſine 110 degrees, that is ſine 70,	997299
to 136 $\frac{1}{10}$ B D.	213461

Alſo to finde A D,

As ſine A D B 16. Compar. 055966
is to A B 40 pole: 160206
ſo ſine D B A 54 degrees 990796
to 117 $\frac{4}{10}$ A D. 206968

Then in the triangle C B A,
C B A is 104 and B A C is 60, theſe added together make 164, which taken out of 180 leaves the angle B C A 16 degrees. Now to find B C.

As ſine 16 d. Compar. 055966
to A B 40 p. 160206
ſo is ſine C A D 60 993753
to B C 125 and $\frac{7}{10}$ 209925

Alſo to finde A C.

As ſine A C B 16. Compar. 055966
to A B 40: 160206
ſo ſine 104, that is ſine 78 C B A 998690
to A C 140 $\frac{8}{10}$ 214862

Laſtly having the two ſides A C 140 $\frac{8}{10}$ and A D 117 $\frac{4}{10}$ and the angle C A D 50 in your triangle C A D to finde C D.

As the ſumm of the ſides 258 $\frac{1}{10}$. Compar. 658804
to the difference of the ſame ſides 23 $\frac{4}{10}$ 236922
ſo is the tang. of $\frac{1}{2}$ the ſum of the angles unknown 65 to the tang. of $\frac{1}{2}$ their difference 11 degrees, 033133
which add to 65 d. $\frac{1}{2}$ *facit* 76 the greater angle D. But ſubtracted from it makes the angle 54 degrees: and then 928859

as ſine 54. Compar. 009205
to 117 $\frac{4}{10}$: 206967
ſo ſine 50 degrees. 988425
to C D 111 $\frac{2}{10}$ 204597

CHAP.

CHAP. XX.

Of altitudes and diſtances celeſtial by the Pandoron or Quadrant.

FOr taking of altitudes and diſtances celeſtial, or altitudes terreſtrial, it is a matter of neceſſity, that beſides your Quadrant and three-legg'd foot, you get alſo a neck or piece of cloſe-grain'd wood, whoſe Diameter may be about three inches, or ſomewhat more. Let the nether end be turned with a ſocket, that inſtead of the ſocket of your Table you may put on that, ſo that it may turn on the top of the ſtaff as the ſocket doth, having alſo a ſcrew-pin in the ſide of it, to hold it at any ſituation. Alſo about two or three inches below the top turn it like a bowl, in the midſt whereof bore an hole with an inch-wimble, to which fit a pin of the ſame wood, ſo hard both driven in and glewed in that it ſtirs not, but let one end thereof be ſo big and ſo long as to fit the braſs ſocket, that the ſocket may turn very ſtiff about it; and let the little end of the pin reach paſt the hole of the bowl, almoſt the depth of the ſocket, and then you may fit that end of the pin either to that or any other Inſtrument, by glewing upon it a piece of its own wood, turn'd like a little ſalve-box; then upon this pin put the ſocket of your Inſtrument, and work as followeth.

To take the altitude of the Sun.

Take the ſtring of your plummet in your hand, and apply it to the edge of your Inſtrument, and hang it plumb: then ſcrew it faſt, then move the ruler with ſights up and down, till the Sun ſhining through the ſight next the limb, the ſhadow of the thread run ſtreight along the rule, then look how many degrees are between the edge of the rule, and the bottom of the limb, ſo many degrees is the height of the Sun: and this you may do by ſetting it on a ſtool.

To take the height of a ſtar.

To do this, having hanged your Inſtrument on the pin of

the neck, and plumbed one edge by the light of a candle, look by the edges of both ſights, moving the ruler till you ſee the ſtar deſired in a ſtreight line with them both, then ſcrew the ruler, and take down the Table, accounting the degrees from the bottom to the edge of the rule for the height of the ſtar.

To take the diſtance of two ſtars howſoever ſituate.

If both be near the Horizon and near of one altitude, and within 90 degrees of each other, you need not uſe the neck at all, but onely lay your ruler on the beginning of the degrees, then ſcrew it, and turn the Table till by both ſights you ſee one of the ſtars; then faſten the Table, and move the ſights to the other ſtar, and the degrees on the limb of the fiduciall edge of the rule gives their diſtance.

If they be both in one and the ſame half of a vertical circle, take both their heights as afore, ſubtract the leſſer altitude from the greater, you have your deſire. If they are in ſeverall halfs of the vertical circle, take the complements of both their heights, and add them together, *& actum eſt.*

But if they lie aſlope, and yet are within 90 degrees one of another, then beſides the foot and Quadrant, or Pandoron, get you two round ſticks as big as your thumb, about ſix foot long apiece, ſharpen their little ends, and nayl their great ends together within five or ſix inches of the top, with one nayl onely, that they may open and ſhut like a pair of tongs; alſo you ſhall take a joynd-ſtool and cuſhion, and having put the neck upon the foot, and the Pandoron on the pin of the neck, cloſe the three feet together with your right-hand, and lay them on the cuſhion, and with your left hand under-ſet the neck with the tongs, opening and ſhutting them as need is, or ſetting them nearer or further from you as need is, all with the ſame hand, and turning it aſlope with the right hand. Then having firſt placed the ſights at the beginning of the degrees, turn it till by the edges of both ſights you ſee one of the ſtars you deſire; then keep the Table faſt there, and move the ſights till by them you ſee the other ſtar, *& voti compos eris.*

CHAP.

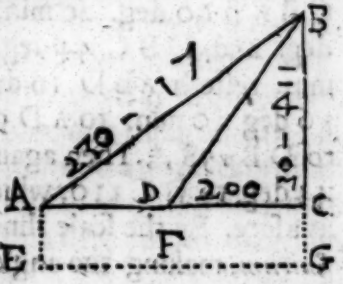
CHAP. XXI.

Of taking of altitudes terreſtrial by the Quadrant.

THere are divers ways whereby theſe altitudes may be diſcovered, whether they be perpendicular, as properly they ſignifie, or Hypotenuſes or baſes: for all of them are comprehended under the notion of *Altitude*; becauſe the baſes may be as well found by the help of the perpendiculars, as perpendiculars by the help of baſes, and any of theſe may be found ſeverall ways by the Pandoron, either as it is a Quadrant, or as it is a Geometrical Quadrat: of either of which we will lay down ſome Problemes, and firſt as it is a Quadrant.

Probl. I. *A diſtance being given and the angle of the baſe, to finde an altitude.*

Meaſure the diſtance A C 200, and the angle A 29 deg. 40 min. by your *Pandoron*, the Complement wherof is the angle B 60 d. 20 m. *ergò* as ſine A B C 60 d. 20 m. 993898 is to the line A D 200. 230103 ſo ſine B A C 29 d. 40 m. 969496 to C B 114 (03. 205700



II. *Likewiſe the height C B given, to finde A C the diſtance.*

As B A C 29 deg. 40 min.	969496
is to C B 114 (03.	230103
ſo B 60 deg. 20 min.	993898
ſo A C 200.	230103

To finde either of them by the ſcale and compaſſes, having the angle A, and diſtance A C.

Firſt draw the line A C, ſet from A toward C 200 of ſome ſcale of equall parts, upon C erect a perpendicular, and upon A make an angle of 29 deg. 40 min. which line will meet C B,

C B, and you ſhall finde C B 114 *feré*. So meaſuring the height C B, and the angle B, and plotting it, you ſhall have A C 200.

III. *The height B C and angle A being given, to finde the Hypotenuſe A B.*

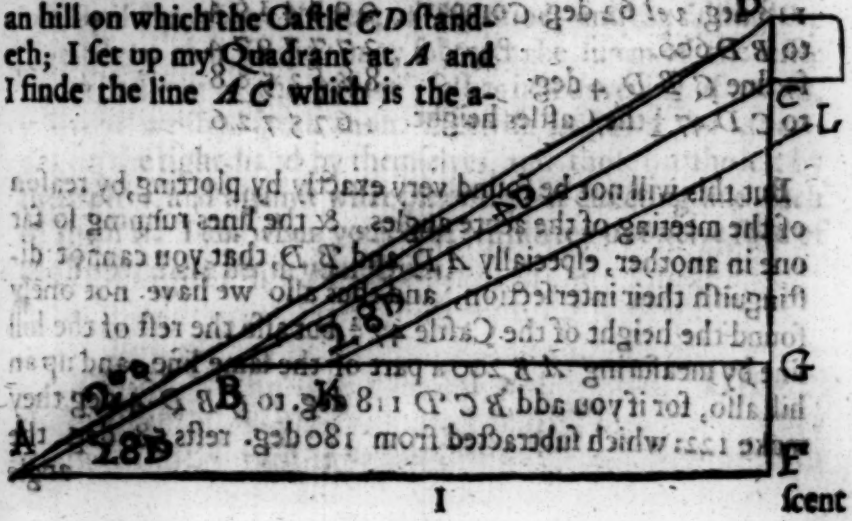
As A 29 deg. 40 min. to B C the height 114 (03: ſo A C B 90 deg. to A B 230 (17. *To finde it by the ſcale.* Draw the line A C let it be 200 of equall parts, upon C erect the perpendicular B C, and on A make an angle of 29 deg. 40 min. ſo the Hypotenuſe A B wilbe 230 (17.

The part of the diſtance D A in the ſame diagram being known to finde D C or A C. Let A D or E F be 90 foot and I deſire F G or D C, but I cannot meaſure it for impediments, therefore firſt take the angle of altitude B at both ſtations A and D, at A I finde A 29 deg. 40 min. ſo that the angle C B A is 60 deg. 20 min. at D I find the ſame angle D 46 deg. and D B C 44 deg. ſubtract 44 deg. from 60 deg. 20 min. reſteth A B D 16 deg. 20 min. then ſay, As ſine A B D 16 deg. 20 min. to A D 90 foot: ſo is B A D 29 deg. 40 min. to D B 158 $\frac{4}{10}$. Then again, As 90 to B D 158 $\frac{4}{10}$: ſo is D B C 44 deg. to D C 110, which added to 90 A D makes A C 200, as afore. By the ſcale thus, draw the lines A C and A B *ad infinitum*, making the angle 29 deg. 40 min. then ſet 90 feet from A in the line A C to D where you found the angle D B C to be 46 deg. becauſe the angle C D B is 44, for they are the complements one of the other, therefore plot the angle B D C and it will be 46 deg. and the B D 158 (4: then from B let fall a perpendicular upon A C, and it cuts it at C making D C 110 and A C 200 as before. To let this perpendicular fall divide either A B or D B into two equall parts, and with the compaſs at that widene's ſet one foot in the interſection and the other in the line D C at C and there falls the perpendicular B C and the end of the line A C.

Likewiſe any part of the altitude being known, the reſt of it may be found by turning the height into the diſtance, and the diſtance into the height.

Any

Any part of the diſtance being known to finde the Hypotenuſe. In the former diagram, ſubtract the angle B D C. 46 deg. out of 180 deg. or (which is all one) add D B C 44 deg. to C 90. there reſts the obtuſe angle B D C 134, to which add the angle B A D 29 deg. 40 min. they make 163 deg. 40 min. whoſe complement to 180 is the angle A B D 16 deg. 20 min. Now ſay, As ſine 16 deg. 20 min. is 50 90 feet: ſo is 134 deg. which becauſe it is obtuſe above 90 deg. you muſt ſubtract it from 180, reſts 46 deg. the acute angle B D C, and they give the Hypotenuſe *A B* 230 (17. And for *D B* ſay, As ſine *A B D* 16 deg. 20 min. to 90 feet: ſo is ſine *D A B* 29 deg. 40 min. to *D B* 158 (4: for the plotting, if you mark how it is done in the laſt probleme, you cannot fail in this. But as for taking all theſe Altitudes aforeſaid, conſidering they are onely to be taken upon plain ground and that the chiefeſt uſe of this skill is to take ſuch altitudes as ſtand upon an hill: (For although ſeverall writers talk of taking the heights of Caſtles, Towers, Forts, &c. yet they deſcribe them all as if they were upon plain ground, whereas it is a common thing to finde a Caſtle on hilly ground: ſo that I know not one Author that gives any rules how to find the height of a Caſtle ſtanding on the top of an hill.) I have therefore here in this diagram demonſtrated the ſame. Let *A C F* be an hill on which the Caſtle *C D* ſtandeth; I ſet up my Quadrant at *A* and I finde the line *A C* which is the a-



ſcent of the hill to the bottom of the Caſtle 28 deg. of height, and the angle F A D 31 deg. to the top, the difference is 3 deg. which is the angle C A D: then I meaſure up in the line A C to B 200 foot: where if you ſuppoſe another horizontal B G parallel to A F, then muſt the angle G B G be 28 deg. as before, by *Euclid, prop.* 28. *Element.* 1. there alſo I take the top line by my Quadrant, *viz.* B D, and finde the altitude thereof G B D 32 deg. the difference is 4 deg. which is the angle G B D and that taken out of 180 deg. leaves the angle D B A 176 deg. by *prop.* 13. *Elemen.* 1. to which add C A D 3 deg. *facit* 179 deg. that taken out of 180 deg. leaves A D B 1 deg. alſo add C B G 28 deg. to C G B 90 deg. they make 118 deg. which taken from 180 deg. reſts 62, B C G. *prop.* 29. *Element.* 1. and the ſame 118 deg. is the angle D C B, for which in the analogie we take 62 the acute angle or complement to 180 deg. for the obtuſe. Now to finde the ſides ſay,

As ſine A D B 1 deg. Compar. 1 7 5 8 1 4 4
to A B 200. 2 3 0 1 0 3
ſo ſine C A D. 3 deg. 8 7 1 8 8 0 0
to B D 600. 2 7 7 9 7 4

Secondly, As ſine D C B 118 deg. *vel* 62 deg. Compar. 9 9 5 4 1 6 4
to B D 600. 2 7 7 9 7 4
ſo ſine C B D. 4 deg. 8 8 4 3 5 6 8
to C D 47 ½ the Caſtles height. 1 6 7 5 7 2 6

But this will not be found very exactly by plotting, by reaſon of the meeting of the acute angles, & the lines running ſo far one in another, eſpecially A D and B D, that you cannot diſtinguiſh their interſection, and thus alſo we have not onely found the height of the Caſtle 47 ½, but alſo the reſt of the hill line by meaſuring A B 200 a part of the ſame line, and up an hill alſo, for if you add B C D 118 deg. to C B D 4 deg. they make 122: which ſubtracted from 180 deg. reſts 58 deg. the

angle

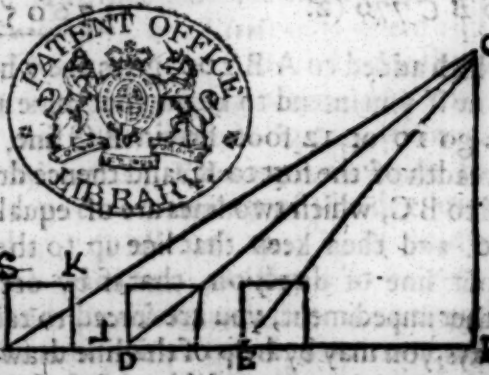
angle *C D B*. Then ſay,

As *C B D* 4 deg.	Compar.	1156416
to *C D* 47 ½:		1675726
ſo *C D B* 58 deg.		9928420
to *B C* 776 (2.		2760562

which added to A B 200, gives the whole line 976 (2. And now if you intend to begin your mine at B, your beſt way is to go 10 or 12 foot firſt in B G line, as you ghueſs half the breadth of the fort to K, and thence draw the line K L parallel to B C, which two lines are of equal length. *Elem. 1. prop. 26.* and then keep that line up to the top, for that muſt be your line of direction, that if by occaſion of ſome rock, or other impediment, you are forced to raiſe, or ſink, or go ſideways, you may by help of this line drawn on paper with a large ſcale, keeping account ſtil how far you are gone in the ſaid line, and by help of the Quadrant at each ſtation, be able to plot how much you are above or below your line of direction, and by help of your Needle to finde how far you are gone ſideways; but your beſt way is to draw one line for aſcents and deſcents, and another for variations ſide-ways, beſides your line of direction, and it will not be labour in vain alſo, beſide both theſe lines to ſet down in a note-book the inches raiſed by themſelves above the line of direction, and the fallings by themſelves, that ſo you may ſubtract the ſumm of the leſſer from the ſumm of the greater; juſt as in conveying of water, whereof we ſhall ſpeak anon. Likewiſe ſet down the variations on the right-hand by themſelves, and thoſe on the left by themſelves, and againſt what part of your directing-line each of them is. Thus when you come within ten or twelve foot of the floor, there begin your Oven,

CHAP. XXII.

Of taking altitudes terreſtrial by the Quadrant, or the Pandoron.



THe ſides of the Quadrat S K, & K I (of which S K is called of *Pitiſcus* the right ſhadow, & K L the contrary) are nothing elſe but the natural tangents of arches leſs then a Quadrant, which if each of theſe ſides be divided by decimal diviſion, they will agree with the Tables of natural tangents, either of *Blundevil*, or *Pitiſcus*, which holds in the contrary ſhadow; but becauſe the contrary ſhadow is not continued ſtreight on, but is turned again at 1000, therefore there it begins to be reckoned back again to 0, as Mr. *Wingates*, or Mr. *Gunthers* rule is. So that now if you turn A S down-ward, then K L will be the right ſhadow.

But to diſtinguiſh the right and contrary ſhadow, you muſt firſt conſider whether your Quadrant goeth with a moveable rule and ſight upon it, as *Pitiſcus* hath it; if ſo, then one edge is always plumb'd, then the right ſhadow is the horizontal above, and the left ſhadow is perpendicular; which if the ruler falls on it, the thing ſeen is lower then 1000 parts by his account. But by *Gunthers* Quadrat, which is with a plummet onely, and the centre upward, the plummet falls in the right ſhadow, when the thing is ſeen lower then 45 degr. of the Quadrant, or a 1000 of the Quadrat. But Mr. *Gunther* hath (in my judgement) expreſſed himſelf in doubtfull terms, in defining right and contrary ſhadow, where he ſaith that the right ſhadow of a Quadrat is that which is neareſt

to

to the horizontal. May I not well ask what horizontal line he doth mean? or where is there an horizontal line in that kinde of Quadrat? Certainly there is none at all; what doth he then mean? he meaneth that that is the right ſhadow, that in taking any height lieth moſt level, and ſo it agreeth with *Pitiſcus*: and although *Gunthers* rules are fully ſufficient for his Quadrant, yet will they not ſerve to *Pitiſcus* without ſome alteration. We will therefore beg leave of Mr. *Gunther* to borrow his rules, and to fit them to both.

1. *Any point being given to finde whether it be level with the edge, by* Gunthers, *thus.*

If looking through the ſights, and ſeeing your deſired mark, the plummet falls in the the down-right line next to you, then it is right and level with the eye. But by the other, fix the ruler on the lower ſide to the beginning of the degrees; then plumb the other edge next the centre; if then by looking through the ſights, you eſpie the mark, then is it level with the bottom of the Table; or if you ſee by the top, then it is level with it.

2. *To finde an height at one obſervation by* Gunthers.

If looking through the ſights and ſeeing the mark, the plummet falling on 100 of the Quadrat, or 45 degrees of the Quadrant, then the diſtance between the mark that is level with your eye it ſelf, is equal to the height above the ſaid mark. But if the plummet falling there, you ſee below it through the ſights, then go further off, if above, then go nearer.

By the other, Firſt, faſten your ſights on 100 or 45 degr. of the Quadrant; then having plumb'd the ſide next you, go further off, or nearer, till you ſee the top deſired through the ſights of the ruler: then by looking by the over-edge of the Quadrat, ſee ſome mark by it alſo: ſo the diſtance from it to your eye ſhall give the height from the mark to the top deſired. And what is here ſaid of 100 of the Quadrat to give the true diſtance, underſtand the ſame, the plummet falling on 50 of right ſhadow, and the ruler on 50 of contrary, then to

give a diſtance double to the height: if 25, the height is but a quarter of the diſtance; if 75, then three quarters: for as often as the plummet falleth on the parts of the right ſhadow, or the ruler in the other on the contrary ſhadow, as 100 to the parts on which the thread falleth, or rule cutteth; ſo is the diſtance to the height required: and contrarily, as the parts cut by the thread or ruler in the ſaid ſhadows are to 100, ſo is the height to the diſtance. But when the thread ſhall fall on the parts of the contrary ſhadow, or the ruler on the right; if they fall on fiftie parts, the height is double to the diſtance; if on 25, it is four times as much as the diſtance: for as often as the thread falleth on the parts of the contrary ſhadow, or the ruler on the right, as the parts cut by the thread or ruler are to 100; ſo is the diſtance to the height; and on the contrary, as 100 are to the parts cut, ſo is the height to the diſtance: and what is here ſaid of the height and diſtance, the ſame may be underſtood of the height and ſhadow.

To finde the height or diſtance at two obſervations by Mr. Gunthers *way, by the Quadrat.*

As if the place which is to be meaſured might not otherwiſe be approached, and yet it were required to finde the height B C, and the diſtance: Firſt, I make choiſe of a ſtation at E (in the laſt diagram) where the thread may fall on 100 parts of the Quadrat, or 45 degrees of the Quadrant, or the ruler cut the like parts, the diſtance E B would be equal to the height B C: then if I go further off in a direct line with the former diſtance, and make choiſe of a ſecond ſtation at D, where the thread may fall on 50 parts of right ſhadows, or the number 50 of contrary ſhadows, the diſtance B D, would be double to the height B C. Wherefore if I meaſure the difference between the two ſtations E and D, and this difference E D will be equal both to the diſtance E B, and to the height B C: or if you cannot make choiſe of ſuch ſtations, I take ſuch as I may, one at D, where the thread cuts 50 parts of right ſhadow, and the rule 50 of the contrary; the ſecond at A, where they fall on 40 parts of their like ſhadows. Then ſuppoſe

pose the height B C to be 100 (for easines of calculation, though it be but 16) I finde, as 50 parts are to 100, the side of the Quadrat, so 100 the supposed height to 200, the distance B D. And as 40 parts at the second station unto 100, so 100 the supposed height to 250, the distance B A. Wherefore the difference between the two stations D and A should seem to be 50, and then if in measuring of it you finde it more or less, the proportions will hold, as from the supposed difference to the measured difference, so from height to height, and from distance to distance: as if the difference between the two stations D and E being measured were found to be 30; As 50 the supposed difference unto 30, the true difference; so 100, the supposed height, to 60 the true height; and 200 the supposed distance to 120 the true distance, and 250 at the second station to 150 the distance B E.

CHAP. XXIII.

To take the situation of a plain for a dial, viz. the declination and reclination thereof by the Pandoron.

APply one edge of your Pandoron to the plain, and the plummet to the edge next you; if that edge be upright, the plain is upright: if it recline, take off the ruler, and apply one of the edges next the centre that are not divided to the plain, so the degree cut by the thread gives the inclination. But if it recline, then turn the centre downward, and holding that thread in your hand, moving it to and fro with your thumb upon it a little above the limb, till the thread fall on the centre: so the degree cutting the line, shall be the reclination. Or you may put on the rule, taking out the sights, turn the centre downward, and one of the sides next it to the plain, turning the rule till the thread fall in the middle of it, then the fiducial edge thereof will give the degree of reclination.

But for the declination: Although you may go somewhat near by help of your needle and card, if there be no

iron

iron near you, yet work as exactly as you can, I will be loth to truſt it, but rather I will go further about, and finde it by the Azumeth; which to do, I muſt firſt by my Pandoron take the angle of the wall and Sun, thus: Apply one of the edges thereof next the centre to the plain, and turn the ruler till the Sun ſhews the ſhadow of the thread of the ſight next the Sun, along the midſt of the rule, then ſhall the fiduciall edge of the ruler give the degree of declination. But you muſt mark whether it be taken in the fore-noon or after-noon, and likewiſe the moneth and day of the moneth: likewiſe you muſt at the ſame moment take the Suns altitude, thus; Either hang the Pandoron on the pin of the neck, or rather ſet one of the undivided edges on a ſtool, and plumb the other; then turn the edge of the Table to the Sun, moving the ruler up and down, till the ſhadow of the thread in the ſight next the Sun ſhine ſtreight along the middle of the rule, ſo the fiducial edge gives the Suns altitude in the degree of the limb. Now knowing theſe things, you may finde the Azumeth either by calculation, or by your Pandoron, if you have *Gunthers* Quadrant drawn on it. Firſt, by calculation having the moneth and day, you know the Suns place by this rule:

10	10	11	11	13	13	13	13	12	11	10	9
Mar.	*Apr.*	*May.*	*June.*	*July.*	*Aug.*	*Sept.*	*Octob.*	*Nov.*	*Dec.*	*Jan.*	*Feb.*
♈	♉	♊	♋	♌	♍	♎	♏	♐	♑	♒	♓

2 tens, 2 elevens, 4 thirteens, 12, 11, 10, 9. Theſe are the days of each moneth the Sun changeth his ſigne, beginning with *March*. If the day you ſeek the Suns place be after the change day in any moneth, ſubtract the change day out of the day you ſeek, and you have the degree of the ſigne of that moneth. *Example.* I deſire the Suns place *April* the 25, 16, 6. I finde by this rule *April* 10, the Sun entred ♉, take 10 out of 25, reſts 15; ſo I conclude, the Sun is in the 15 degree of ♉ that day.

But if the day you ſeek be before the change day in any moneth, then firſt you muſt ſubtract that day from the change day, and then the remain always from 30. So *April* the fifth take

take five out of ten, there remaineth five; and that taken from 30, there reſts 25 degr. which being it is Leap-yeare, you may make it 26 of ♈, of the moneth preceding.

Then you muſt ſeek the Suns declination either out of ſome Table for that purpoſe, or by this analogy: as the *Radius* to the ſine of the Suns greateſt declination 23 degr. 30 min. ſo is the diſtance from the neareſt Equinoctial to the declination deſired. Suppoſe *April* 5. the Sun in 26 degr. of ♈, that is 26 degr. from the neareſt Equinoctial; ſay, As the *Rad.* to the ſine of the Suns greateſt declination 23 degr. 30 min.

	23 degr. 30 min.	960070
	26	064184:
ſo is the diſtance from the neareſt Equinoctial to		
the declination deſired 10 degr. 4 m.		924254

which becauſe it is in a Northern ſigne, as ♈ ♉ ♊ ♋ ♌ ♍, therefore it is North declination, and is ſo much nearer then 90 degr. to the North-pole, as the Suns declination is, *viz.* 79 degr. 56 min. Now add this diſtance, the complement of the altitude, and the complement of the latitude, all three together, and from the half ſumm ſubtract the diſtance from the pole, and note the difference. Let us ſuppoſe the Suns altitude taken about nine of the clock in the morning for the latitude of 52 degr. 15 min. took by the Quadrant as you are directed in *Chap.* 20, to be 32 degr. then proceed thus; The Suns North declin. 10 deg. 4 m. diſtance from the pole 79 d 56 m.

latitude 52 degr. 15 m. complement		37	45
the Suns altitude 32 degr. complement		58	00
Now ſay, As the *Radius* 90,	Summ	175	41
to ſine of the compl. of	half ſumm	87	50
altit. 32 d. *i.e.* S. 58 d. 992842.	hence take	79	56
ſo coſine 52 d. 15 m. or	difference	7	54
S. 37 d. 45 m. 978690.			
to a 4th ſine 21 d. 17 m. 971532.			

As this fourth ſine 21 d. 17 m. Comp. Ar. 028467
to the S. of the half ſumm 87 d 50 m. 599969
ſo is the S. of the difference 7 d. 54 m. 913813
to a ſeventh ſine 15 d. 20 m. 1942249
Add to it the *Radius*, the half (971124 30 d. 58 m.)
thereof is the mean proportional, being the ſine of 30 d. 58 m. whoſe comp. is 59 d. 2 m. that doubled is 118 d. 4 m. the Azumeth from the North.

Now ſuppoſe you had taken the wall and Sun 40 deg. that muſt always be ſet backward in the courſe of the Sun from the Sun or *Azumeth*: *viz.* from Weſt to South, from South to Eaſt, &c. ſo then our angle of wall and Sun being taken in the morning, the Sun muſt needs be on the Eaſt-ſide of the Meridian line, and being found 118 deg. 4 min. from the North, that is 28 deg. 4 min. beyond the Eaſt, now if I ſet back 40, that is take 28 deg. 4 min. out of 40. there reſts 11 deg. 56 min. from the Eaſt toward the North; and there was the Sun when firſt it ſhone on the wall thence draw your wall-line through the centre, and always the diſtance between the Eaſt or Weſt-line and the wall-line is the declination deſired 11 deg. 56 min. as afore in *Chap.* 14. Now becauſe the Sun ſhines on it at noon: therefore it is a South diall; and becauſe the Sun ſhines on it longer in the fore-noon then in the afternoon, therefore it is a South declining Eaſt-ward 11 deg. 56 m. But if having the day of the moneth *April* 5, you take it in the morning and the Suns altitude 32 deg. and the angle of the wall and Sun 40 deg. as afore, and you have *Gunthers* Quadrant drawn on your Quadrant for your own latitude, and that you have your line of the Suns declination drawn on the ruler as well as on the left-ſide of the Quadrant. And thus you deſire to know all things by it without any calculation; Firſt lay your ruler on the day of the moneth, ſee what degree of declination is cut by that 12 of clock hour which is proper to the time, whether it be ſummer or winter, carrie that degree

gree to the Ecliptique and you have the Suns place. Alſo carrie it or take the ſame degree in the declinations on the left ſide, it gives the time of Sun-riſing in the fore-noon-hours and the ſetting in the after-noon. Lay the ruler on the deg. of the Suns altitude in the limb reckond from the left-hand, and your deg. of declination gives the hour of the day: carrie it to the right-ſide and reckon the altitude from thence, and the ſame deg. of declination gives the Azumeth either for ſummer or winter: but not from the North, but from the South. Then may you caſt up your declination of the wall, having your Azumeth as you did before, or elſe finde it by help of a ſcale of chords drawn toward the top of the Quadrant on the right hand with a circle of the Suns *Radius* divided with two croſs Diameters, and marked with Eaſt, South, Weſt, North, and thereby with your compaſſes take your diſtances from your ſcale and ſet them out upon your circle. Further if you bring your deg. of declination upon your ruler to the Horizon, you have the Suns Amplitude in the Horizon alſo lay your rule on the place of the Sun in the Ecliptique it gives its right aſcention. If you bring your deg. of declination to the Horizon, the edge of the rule ſhewes in the limb the Aſcentionall difference; which known, turn this Aſcentionall difference into time, allowing an hour for each 15 deg. and 4 min. of an hour for each deg. it ſhews how long the Sun riſeth before ſix of the clock in ſummer, and after ſix in winter. If you bring the degree of the Suns declination in ſummer to any of the winter hours, and for morning hours of the one take the afternoon hours of the other, it gives in the limb the depreſſion of the Sun below the Horizon. Bring the ruler to 18 deg. of the limb, and ſee where in ſummer the deg. of declination cuts the winter after-noon hours, and that hour is the break of the day: but in the fore-noon hours for day-light ſhutting in and the contrary; lay your ruler on the day of the moneth, make a mark upon the rule, where it cuts the ſixth hour in *Facts* Quadrant, then lay your ruler on the Suns altitude in the limb and your mark, which give you the planetary hour. But it was

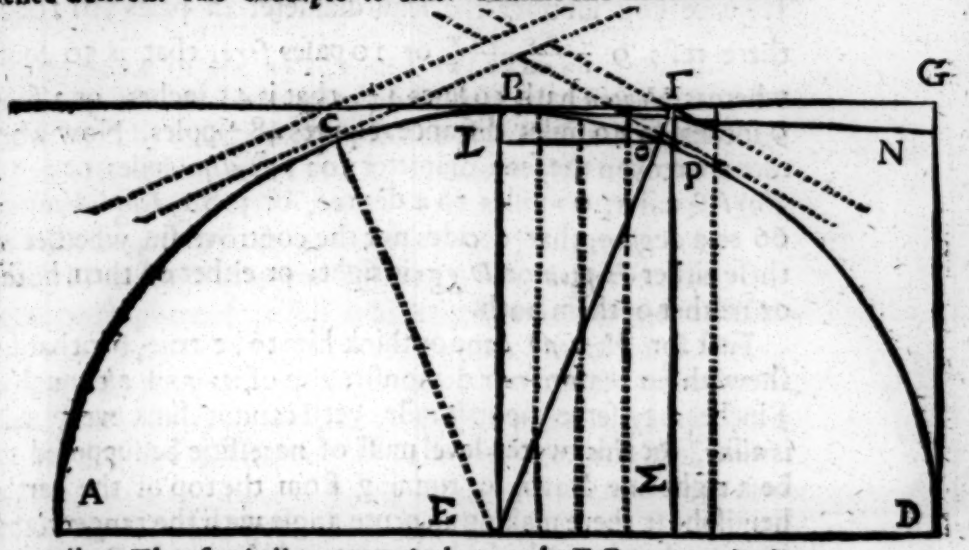
not my purpoſe to ſhew all that may be wrought by the Pandoron, ſo I may have work enough for a good while; but onely to ſhew the uſe of it in meaſuring of land, taking of altitudes, & conveying of water. They that deſire more of the making & uſe of it in theſe things, let them ſee *Gunthers* book it ſelf, or for the uſe of it let them ſee a little book thereof by it ſelf ſold by Mr. *Moxon* at the ſigne of the *Atlas* in *Corn-hil*, together with printed papers of the ſaid Quadrant for *London*-latitude onely. But if any deſire the making of it for other latitudes, let them peruſe my *Fale redivivus* or *Sun-ſhine of ſhadows*, wherein they ſhall finde *Gunthers* firſt chapter touching the making of this Quadrant explained, with Tables to make it for all latitudes throughout all *England*, and alſo Tables for all Horizontall dials, and for all erect South and North, Eaſt and Weſt, and all decliners from one deg. to 90 for each whole deg. as alſo for all Polars, and all theſe for nine ſeverall latitudes from 50 to 56, as alſo divers others curious dials Quadrants and Nocturnals.

CHAP. XXIV.

Of conveying water.

I Find great difference among our beſt Authours concerning the odds or difference between the true and water-levell. Mr *Hopton* in his 24th chapter of his *Topographical-glaſs* ſaith, that after the ordinarie manner to bring it in pipes, the ground muſt be lower by 4 ½ inches for each mile, then at the ſpring-head: ſo that I ſuppoſe his meaning is, if it be 10 miles, it muſt be each mile alike, *viz.* ten times 4 and ½ that is 45 inches, or three feet nine inches; but neither demonſtrates it nor gives any reaſon for it. Again Mr *Diggs* in his *Pantometria* (*lib.* 1. *chap.* 3.) ſaith that in ten miles diſtance, the water-level is below the true nine paces, four foot eleven inches: which if every mile give a like we have five foot in a mile. And becauſe there is ſuch a vaſt difference, I will lay down both *Diggs* his rule to finde it, and his example, as he calculated it in his own words:

words: his rule is thus. First it behoveth you to get the diſtance of the fountain from the place whither you will convey the water, which diſtance you ſhall multiply by it ſelf, adding the off-come to the ſquare of the earths ſemidimetient, and from the ſumm extract the ſquare-root, and out of which root ſubtract the earths ſemi-diameter, the remain is the difference deſired. His example is this. Admit the diſtance B E



10 miles. The ſemi-diameter of the earth E B 5011 *Italian* miles. But how the ſemi-diameter can be 5011 *Italian* miles, I cannot imagine: for if the ſemi-diameter be 5011, the whole diameter muſt be 10022, which multiplied by 22 gives 220484: that divided by 7 gives 31498 the circumference, which divided by 360 deg. gives 87 ½ *Italian* miles to a degree.

Now becauſe an *Italian* mile is 1000 paſes, and an *Engliſh* mile 1056, ſay, As 1056, 1000: 87 ½. 82. So that by this account there ſhould be 82 *Engliſh* miles to a degree, which was never heard of; our common account is but 60. our modern Artiſts hold 66, the moſt that ever was reckoned of is leſs then 69, but this is 13 more.

But ſuppoſe the ſemi-diameter to be, as he ſaith, 5011 and

the diſtance 10 miles, each mile 1000 paſes, each paſe five foot; the ſquare of 10000 paſes, that is 10 miles, the diſtance is 100000000, and the ſemi-diameter in paſes is 5011000, the ſquare thereof is 25. 1101, 2100, 0000, add both theſe ſquares together, they make 25110221000000 hence extract the ſquare-root, it is 5011009 $\frac{9801919}{10012019}$ If hence you ſubtract the ſemi-diameter in paſes 5011000, there reſts 9 $\frac{9801919}{10012019}$ or 10 paſes *ferè*, that is 50 foot, whereas *Hopton* hath 10 lines 4 $\frac{1}{2}$, that is 45 inches, or 3 foot 9 inches; ſo 40 miles diſtance requires 48 $\frac{1}{2}$ poles. Now whether we reckon the ſemi-diameter 5011 *Italian* miles, or 3436 *Engliſh* miles, 60 miles to a degree, or 3780 *Engliſh* miles, 66 to a degree, that decides not the controverſie, whether of theſe either *Hopton* or *Diggs* is right, or either of them both, or neither of them both.

Firſt for *Hopton* I cannot think him to be true; for that he ſheweth no reaſon, nor demonſtration of it: and although 4 $\frac{1}{2}$ inches may ſerve the firſt mile, yet I cannot think every mile is alike, for this water-level muſt of neceſſitie be ſuppoſed to be a right line drawn or running from the top of the earths hemiſphear, there making an acute angle with the tangent, and running between the ſaid tangent and the earths Perimeter, ſuch as the tangent-line B G in the laſt diagram. Now there may be infinite ſuch lines ſuppoſed between the ſaid tangent and the earths circumference, and is there not as good reaſon for all, as for any, for one as for another; there muſt be a *terminus ad quem* given, as well as a *terminus à quo*.

Beſides all this, all theſe lines will be in the aire above the earth; but the water muſt not run above the earth (that is Gods decree) but in the earths Perimeter.

Therefore this difference of levels muſt needs be a line falling from the tangent-line, that runneth from the top of the earth to any diſtance deſired, which (according to *Digs*) is the exceſs of an Hypotenuſal above the *Radius*, or earths ſemi-diameter, running from the centre of the earth to any diſtance of miles,

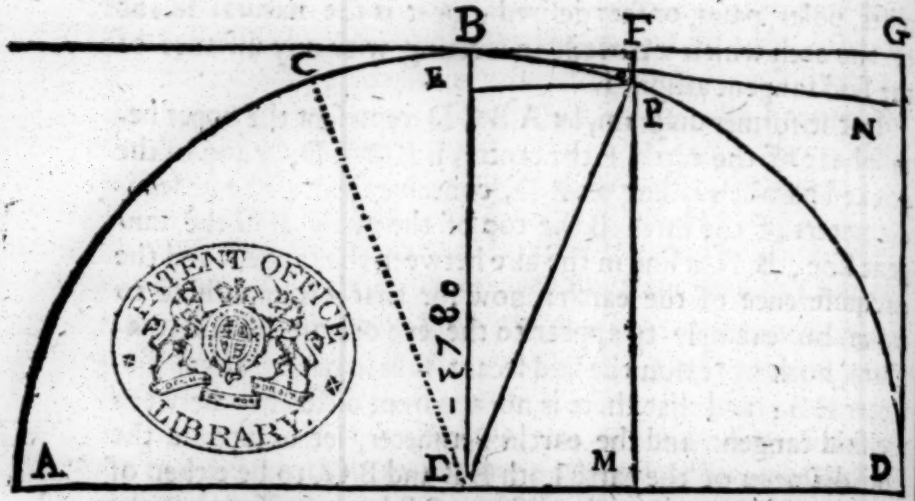
miles, poles, paſes, or feet deſired; or it is the natural ſecant of the arch which it cutteth in meeting with any diſtance of the ſaid tangent aſſigned.

In the former diagram, let A B C D repreſent the upper hemiſphear of the earth, E the centre, E B or E D, or any of the pricked parallels falling on E D, conceive them all to be ſemi-diameters of the earth, B the top of the earth, B G the tangent line, B N a line in the aire between the tangent and the circumference of the earth: now for that it is impoſſible to make his example to appear to the eye out of the ſaid diagram, both by reaſon the ſaid ſecant falls ſo near the ſemi-diameter E B; and that there is no apparent difference between the ſaid tangent and the earths Perimeter, let us ſuppoſe the ſemi-diameter of the earth both E B and B G, to be either of them 100 miles, and let the diſtance B F be 40 miles, then the ſecant or Hypotenuſe is E F, which for that it is longer by F O. then E B; therefore F O. is the difference of the levels found, as is before declared.

And although *Dig.* neither doth ſet down the reaſon of his finding it after this manner; yet it is eaſily perceived of every one that hath any underſtanding in triangles: for it is but the finding out of the Hypotenuſe of a rectangle right-line triangle, having the two leggs given, and it may alſo be wrought by the Logarithmes; but with little leſs labour.

Some think alſo that the line F P is the difference of the levels: but ſince the difference in 100 miles is almoſt inſenſible between thoſe two, we will onely demonſtrate it to you, and then let every man uſe his own diſcretion.

Let



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Let us ſuppoſe in this diagram A B F D the upper hemiſphear of the earth, whoſe ſemi-diameter E B is 3780 *Engliſh* miles, 66 to a degree, to which is equal both B G, and F M, and E D: for E D is equal to E B, *Element.* 1. *Defin.* 15. and B G and E D. *Element.* 1 *Prop.* 36. therefore it is equal to E B, *Axiom.* 1. *Element.* 1. and F M is equal to E B, *Elem.* 1. *Def.* 15. and B G, and E D *Elem.* 1. *Prop.* 36. therefore equal to E B, *Axiom.* 1. *Elem.* 1. and M E is equal to F B, *Elem.* 1. *Prop.* 36. And becauſe in the other example we could not diſtinguiſh one thing from another, becauſe of the nearneſs of things one to another; therefore we will take the diſtance B F, which ſuppoſe 1500 miles, which (to ſave labour) we will keep ſtill in miles.

Firſt therefore, to find E O, E F, and O F, firſt E O is = to E B, *Elem.* 1. *Def.* 15.

for E F ſquare E B, 3780. it is	14288400.	
alſo ſquare B F, 1500, it makes	2290000.	
theſe added make	16538400.	
whoſe ſquare root E F is *Engliſh* miles	4066 ¼.	
Whence take E B, equal to E O. *Elem.* 1. *Def.* 15.		3780.
reſteth O F, *Engliſh* miles		286 ¼.

Then

Then to finde B E F.

As 3780 Comp. Ar.		642250
is to *Radius*:		
so is 1500		317609.
to tangent 21 d. 39 m. of B E F,		959859.

whose arch is B O, whose natural tangent B F is 39694 parts, and that is equal to L P. *Elem.* 1. *Prop.* 36. which is sine of 23 d. 24 m.

for as	3780	3,577492.
to *Rad.* So	1500	13,176091.
to S. 29 d. 24. m.		9,598599.

whose complement is 66 degr. 36 m. and the sine thereof M P 91775, and the versed sine thereof F P, is equal to L B 8225 parts.

And to reduce them into miles, say, 100000. 9225 :: 3780. 3111. F P. whence take O F 286 ¼, the difference is 24 ¼ miles difference in 1500.

But how can we do so? since Mr. *Frost* (then Manciple of *Emmanuel* Colledge in *Cambridge*, since Sword-bearer to the Lord Maior, and since that a Secretary to the Councel of State, a man beyond all exception for integrity of life, an excellent Mathematician, one that brought the water from the Spittle-house to *Emmanuel*, and thence to *Christs* Colledge,) told me, that he came upon a time (by mere accident) in the Fenns to a place where an old river had run down some four miles, and was brought four miles back again in a new cut, and when they met, the water in the old was but four inches above the water in the new. Now the question is this, Doth not this confirm, or rather out-vie *Hoptons* tenent of four inches and an half to a mile, seeing here is but four inches in eight miles, which is half an inch for a mile? Truly I think not, for whersoever you conceive your self to be, there is the true top of the earth: if there you are withall neither above nor below the true circumference of the earth, such as I conceive the Fenns for the most part to be, having formerly been made level, as being part of the sea, I see not but that the water may

run both ways as well as in the ſea, if not all four ways, as well as the four rivers in the garden of *Eden*. And by this means if the meeting place was not ſome bowing of the earth of four inches thick, why might not they have met of equal height.

Every one (I ſuppoſe) will confeſs with me, that I being at B, the water will run to C, and to o; and if you turn C uppermoſt, will it not run from C to B as well? are no places uppermoſt but B, becauſe I am not there: certainly I am ſome wonderfull vertuous fellow: well, I will get thither, and then it will run thither. If any diſlike this anſwer, let him give us a better.

CHAP. XXV.

Of Inſtruments for conveying of water, and their uſe.

IF your diſtance be not above an 100 poles or thereabouts, you may hang your Pandoron or Quadrant on the pin of the neck, and then ſet up a ſtaff, or rather let one hold it upright, with his face toward you at the head of the water, moving a ſheet of paper up or down, as you, ſtanding 8 or 10 pole off in the water-way, ſhall direct him by the ſigne of your hand, till you having there ſet up your Inſtrument, and plumb'd it truly level, you ſee either through the ſights, or over ſide of the Quadrant, the nether edge of the paper; having firſt ſcrewed the ruler faſt, and placed the thin edge thereof preciſely upon the upper Horizontal line of the Inſtrument: now take not your ſtations above 10 pole at the moſt from your ſtandings, both in regard of the refractions of the air which will deceive your ſight, as alſo for that though your Inſtruments be never ſo true, yet if you fail either in your plumbing it, or in laying your ruler but one tenth part of an inch falſe, (which is eaſily done) you will fail ſo many tenths as are Tables lengths between your Table & your ſtaff; which if your Table be 18 inches *Radius*, and your ſtation ten pole, will come to eleven inches in that diſtance, enough to mar your whole work.

Now

Now he having placed his paper, let him bring it ſtaff and all to you without ſtirring it, and then you having a two-foot rule, and a ſtick in your hand about four foot and an half long, meaſure firſt the height of your ſights above the ground, alſo from the bottom of his ſtaff to the nether edge of the paper: if both be alike, then thoſe two places are level; if not, then ſee which is moſt, and how many inches there are odds: if his be more then yours, then your ground is riſen more then his, ſo many inches as the difference is; but if you are more then he, then you are lower, and then the water will run, or elſe not. For it will never run higher naturally upward, unleſs your former falls do countervail your riſe.

Having thus found the difference, you muſt in a note-book make two Tables, one for the riſings, and another for the falls at each ſtation, with their titles of riſing and falling over them, and the number of inches at each ſtation, and the number of the ſtations on the left hand: and you may do well alſo to meaſure the diſtance with a chain, and ſet down on the right ſide the diſtance from the ſpring-head, and at each ſtation to obſerve ſome mark. And having all done, you muſt caſt up the Tables each by it ſelf, the inches of the falls by themſelves, and the aſcents by themſelves: then ſubtract the leſſer total from the greater, if the deſcents be moſt, it will run, ſo that there be no ſtation in the way that is higher then the ſpring-head: which if you ſuſpect, caſt up both your Tables onely ſo far, and you may eaſily know. Yet if it ſhould, that will not cut you off altogether; for though you cannot help your ſelf by digging deep, yet it is hard, if you cannot by going about.

Having thus meaſured and found the difference, you may for triall-ſake exchange places, and let him ſtand where you ſtood, and do you ſtand at the fountain. If there you finde the deſcent to be the ſame as you did before, all is right: and that you will hardly do, unleſs your Inſtrument be both very large, and very exact.

But now you muſt know, that there is a difference between

your being between the ſpring-head and him, and his being between it and you: for now, if he be moſt, he is loweſt, for always he that is moſt is loweſt.

Now if you will, you may either your ſelf go on forward, and let your aſſiſtant ſtand; or rather your ſelf ſtand there ſtill, if you remove not to prove, as I ſaid; and ſo you may take two diſtances at one ſtation; eſpecially, if you have two aſſiſtants, and all you three are in one direct line: ſo if you keep your work in a ſtreight line, if two aſſiſtants ſtand in the water-way, if you ſtand in the middle in a right line, if you ſee to one of them, you ſee to the other without ſtirring the Inſtrument any ways.

Again, ſo far as you go in a direct line, if you have once ſet two marks level, you may eaſily by them ſet up a third and fourth as far as it goeth in a ſtreight line, and when it turns then uſe your Inſtrument as afore.

Alſo it ſo falls out that water is to be brought out of ſome pond or level water: if you bore holes in two boards like trenchers, and ſharpen ſticks of equal height with white papers on them, if the boards lying in the water, two aſſiſtants hold the ſticks that you may ſet up a third in a ſtreight line with them, with a mark upon it agreeing level with the other marks; if they are too high remove them lower but both alike, or your own higher, *& contrà*: onely take juſt notice how high the two are above the water, and then go on with a fourth and fifth ſo long as you go in a ſtreight line, and then uſe the Inſtrument as afore.

Alſo it may happen that you deſire to bring water from ſome ſpring or head, but you have neither level, nor level water, nor ſtreight water-way, but you ſuppoſe it will run, and the way is not long, and you would willingly try;

Firſt then begin at the head, and make a little trench of three or four pole long towards the way that it will run ſtreight, whether this be ſtreight or crooked it matters not; then let run ſo much water as may onely fill this trench: if you finde it dry, or ſhallower of water at the head, then at the other

other end, it ſhews the ground to be falling; then do the like with three or four poles more, ſtill making the water to follow you, till you be gone three or four pole in your ſtreight line, then having fill'd it that the water may ſtand level at both ends, ſtick up two ſticks, one at one end, the other at the other, of equal length about four foot above the water, then go on 10 or 12 pole in the ſame line, where ſet up a mark, ſo that you ſtanding behinde it, and looking to the middle mark, either all the tops or all the bottoms, according to which you meaſured your equal heights, may agree, then if that ſtick be longer beneath the mark then the other two, it ſhews deſcent: if any riſing places be in the midſt, you may eaſily finde their riſe by ſetting up a ſtick, and meaſuring it as before.

For finding how high you may ſet your cock in a houſe, ſee the laſt page of this Book.

But for long diſtances, although I have fully ſhewn the uſe of it already in the Pandoron, yet becauſe of the ſhortneſs of the lines, there is as little reaſon for to uſe that in doubtfull caſes, as for one to ſhoot at wild-geeſe a furlong off with a piſtol, or to take on obſervation with a Quadrant of 3 inches *Radius*. I will therefore here give the making of a moſt excellent Inſtrument, ſoon made, and cheap enough. Firſt, let

A B be a piece of deal, or ſome light and ſoft wood, about two inches ſquare, or inch and half, and ſeven or eight foot long: in the upper-ſide thereof let there be a groove or chanel made with a round plane, like the chanel for a bed-cord, about an inch wide, and of like depth: likewiſe let E D and F D be two pieces of an inch broad a-piece, and a foot long, and half an inch thick a piece, to make brackets to be lapp'd one over the other at D, and likewiſe the beam with ſcrew-pins made of pieces of old keys, to ſcrew onely into the wood, without any forills at all, and likewiſe an other piece D G of ſix foot long, a quarter of an inch thick,

and an inch broad, with a jage-ſtroke down ſomething toward one ſide of it, that you make the ſcrew-holes beſide it: this muſt be ſcrewed together with the two brackets, within an inch of the end, all three with one pin. Alſo you muſt ſcrew it to the beam at C, that the jage-ſtroke may be exactly perpendicular to the beam: this hole muſt be bored cloſe to the bottom of the groove, and in the bottom of the beam you may glew on a piece of ſome eighteen inches long, in the middle, of two inches broad and an inch thick, to thicken it; becauſe juſt in the middle you muſt make an hole ſo big and ſo deep, that it may fit to go on the top of the three-foot ſtaff, or foot of the Pandoron, when both it and the neck are took off; yet you muſt take heed you bore it not quite to the groove, and let it go on as ſtiff as you can poſſibly. Alſo at either end glew on a piece of an inch thick, eight inches long, and of the breadth of the beam, or nayl them on to the beam, and cut the baſes true and ſquare: then get two thin ſights made after the manner of this figure, eight inches long, and nayl them on to the ends at A B, ſo that the ſight-hole of the one may look over the flat of the other, and when you will uſe it put it on the ſtaff, and put on a plummet and thread of the length of the jage-ſtroke; then ſet it up and move it by the feet till the plummet hangs right with the jage-ſtroke, then fill the groove with water; if it be truly plumb'd and that ſet perpendicular to the beam, then may you fill the groove ſo full of water, that it will riſe ſo high above the wood at both ends, that you may thruſt a needle through it cloſe to the beam, and yet the water will be above the needle.

CHAP. XXVI.

Of flowing of grounds.

MIne intent is not here to deſcribe the manner of making engines, ſluces, *Cochleæ*, mills, &c. to mount the water

ter withall, as being too great a charge for a ſmall piece of ground of nine or ten acres: for it often falls out, that if a piece of ground be ten acres, yet all of it will not be overflowed; ſo that, if you beſtow any great coſt, we may ſay —*materiam ſuperabit opus*: yet this I have ſeen in one of theſe dry years in a meadow near *Hartford*, that one man, having a piece of ground encompaſſed with the river, flowing it made five pound of an acre of his firſt crop, where his neighbour made ſcarce twenty ſhillings an acre of the ground adjoyning; although naturally in other years before as good. Yet this is not comparable to land-flouds; for theſe, partaking of a ſlimy and muddy ſubſtance, being brought into meadows or paſtures in the ſpring, either by drains, dams, turning of town-ditches, ſewers, high-ways, ſtreets, filths, do both moiſten and fat them; wheras the river-water fats nothing ſo much: as *Virgil* hath it,

— huc ſummis liquuntur rupibus amnes,
Declivémque trahunt limum. —

And in another place,

Et cùm exuſtus ager morientibus æſtuat herbis,
Ecce, ſupercilio cliveſi tramitis undam
Elicit, illa cadens raucum per levia murmur
Saxa ciet, ſcatebriſque varentia temperat arva.

And doth not all the world know how the river *Nilus* fats with his ſlime the whole land of *Egypt*?

But now having by drains and dams brought your water to the higheſt part of the ground that you would flow, you ſhall cut a little trench, as level as you can ghueſs by the eye, which in your ground let not be above nine inches broad, and ſeaven or eight inches deep, for going not above a pole at once, laying your turves on the lower ſide of the trench and cloſe by it with the graſs downward; that, if you think good, you may put them in again, or carrie them away: and now let in ſo much water, as will fill up that trench. If you have the water run over at the laſt end a little, it is the better; that ſo, ſtopping your trench with a turf, your water may run over in any place.

place. But if you are riſen ſo, that the water will not follow you, then you ſhould have a ſpade for the nonce with a long crooked handle crooking up like a fire-ſhovel, that therewith you may deepen your trench, and take out the moulds; and then go a little lower the next time, ſtill making the water to follow you as you go to the further-ſide of the ground; then according as the ground falls you may make a croſs-trench, one or more, in the middle, or at ends four or five pole downward; and at every four or five pole make trenches the ſame way you did at the firſt, till you have done: ſo that you ſhall need no water-level for this work, unleſs perhaps you need it to try whether it will come to the ground or no:

If you are to bring it over ſome ditch or brook, where the water is lower then your water-way; then muſt you either make a bridg over it, or elſe ſhoot four boards, and nayl them together, and make a trough, which may lie both under the ditch, and through the mounds of the ditch.

CHAP. XXVII.

Of drayning of grounds.

THe drayning of grounds is often found to be as advantageous and profitable, not onely in arable, but alſo in low meadows, and woods, and bogs upon hills, as the flowing of them: if not far more, by reaſon more grounds, for the moſt part, will be drained, then flowed, both in leſs time and with leſs charg.

The Inſtruments for this work may be a plow, ſpades, ſcopets, ſhovels, and bills, and forks.

In ſome Pariſhes they have a town-plow, that will hold eight or nine yoke of oxen, and a couple of horſes afore for boys to ride on to guide them, and three or four horſes with drivers on them, others to hold the plow (one one while, another another while) booted up to the middle, others following with bills, forks, ſpades, ſcopets, ſhovels, that, if any graſs, or turf-ground fall in after the plow, ſome may

cut

cut it to pieces with their bills, and others throw it out with their forks; but in plowed grounds with ſpades, ſcopets and ſhovels: thus yearly, about *All-Saints*, do they ſerve their peaſe-ſtubble, barley-ſtubble, and low meadows, eſpecially commons. But this plow muſt have a piece of wood either ſcrewed or cotered to the right-ſide of the beam ſomewhat toward the fore-end of it, to make another coulter-hole; that in ſward-ground you may put in another coulter, that may cut both ſides of the furrow: and let the ground-wriſt be five or ſix inches broad, and the broad-wriſt be longer, and ſtand out broader then the ground-wriſt by an handfull, to throw both earth, and turf a good way off. But, if you are in clay-ground, you may make a broader point then on ſtones or gravel; but howſoever let there be a whole pan and a finne-ſhare.

Thus if you will make any new drain, ditch for quick-ſetting, brook, or river: firſt ſet up your mark at each nine or ten pole on both ſides for the riders to guide on the horſes, then plow once all over that breadth, and throw out the moulds; then ſet your horſes ſingle, and with any other lighter plow plow again and throw out, till you are deep enough: thus may you do more in an hour then in three days otherwiſe.

Likewiſe, I have known divers high-ways, where one furlong hath abutted upon them, and another run long-wiſe by the ſide of it, where the way hath not been above a pole broad, that the plow continually carrying out moulds upon it hath ſo rayſed that linſy-ſide, that it hath been ſo linſy that not a loaden cart hath gone on it in harveſt or hay time ſince the memory of man, yet the moſt neceſſary harveſt-way; this have I mended, and made level with mine own plow and mine own people in two hours, a quarter of a mile together; and the like have I done to raiſe a road-way in the middle by plowing and throwing up both ſides.

Alſo I have known one Mr. *Field* of *Aſpley-bury* in *Shidlington* pariſh in *Bedfordſhire*, who there with his plow made a larg moat onely by plowing and throwing out the moulds, and making a ware for the horſes to go in and out.

The ſame man alſo being at an eſpecial friends houſe in *Hartfordſhire*, his advice was requeſted about cleanſing of a brook, which was filled with ſtones driven down the hill by land-flouds, neither could they dig it with ſpades, nor ſtrike in a mattock; if they did, the water would fly in their faces, and the cold water overflowed the banks winter and ſummer, and ſpoiled all about: he gets a ſtrong plow with a narrow-pointed ſhare, and plows one hour in the fore-noon, and gets good ſtore of labourers with forks and ſhovels, and throws out what the plow had raiſed, and then to plow another hour in the afternoon: and thus made quick ſpeed without trouble or let.

Another time the ſame man ſtock'd up a wood; and having onely ſtockt up the wood, he makes a plow, whoſe neck and handle were both one piece: with this plow he plows this ground, and never digged at all, onely he had two following him with mattocks, that if the plow was hanged in the middle of a great root, that the horſe could not break it, then they cut it in ſunder.

And laſtly, one exploit more was by a plow done by Mr. *Taverner* of *Hexton* in *Hartfordſhire* Eſquire, Lord of the Town, who (becauſe their high-way to *Luton*-market was up an extream ſteep hill for two or three furlongs ſpace, and often-times both in froſt and rain ſo exceeding ſlippery an horſe could ſcarce ſtand, being all a rock of hurlock;) gets a plow, and the neighbours willingly bear him company: they plow about in a ſpiral line, and ſo plowed furrow after furrow, all one way, turning all the mould down the hill; and ſo when they had plowed it broad enough once over, then they begin and plow two or three furrows of the moulds twice over, and the higheſt ſide deeper: thus doing, till they had made the higheſt ſide loweſt onely by plowing; ſo that they can now draw five quarters of wheat more eaſily up that hill with three horſes, then up the other with five.

And thus have we the way to drain ſuch grounds, wherein you may have the help of the plow. It follows now to ſpeak

of

of thoſe that muſt be done either chiefly by the ſpade, or one-by the ſpade. Chiefly by the ſpade, called water-furrowing, that is, when you have new ſown any grain whatſoever, then preſently water-furrow it, either with plow or ſpade, or both.

But if it fall out that in a floud the water goes not away ſo faſt as it comes, though within two or three days after it will be clean gone; yet you are never the near, it hath done already what hurt it can do, your grain is drown'd, and the fault is in the main drains, yet not in their depth, becauſe they will be dry within two or three days after, but in their breadth.

Now, if this had been a new drain, you might have made it with the plow, as was ſaid before: or if you will deepen this old one with the plow, it may be you may; but to make it broader you cannot, if it be either very deep, or very narrow in the bottom: therefore you muſt widen with the ſpade onely.

And for that where cattel go over ſuch drains, they commonly tread in the earth, and ſtop up the water, therefore to prevent it, get good oaken timber, hew two ſides of each piece, which let it be eleven or twelve inches Diameter, ſlit theſe in the middle, let them be two or three foot longer then the breadth of the ditch, lay them edge to edge, the ſawn ſide upward, nayl ledges on the out-ſides, and lay gravel or earth on the top, and ſtop up with buſhes, or ditch up, or both, the old going over.

For bogs and quagmires.

Theſe for the moſt part come of ſpewing ſprings that are in a vein moſt commonly of gravel, near the ſuperficies of the ground, and drawn ſtill more upward by the heat of the Sun, or elſe in ſuch places as formerly have been all water, as the Fenns ſometime have been, and ſo growing of weeds at firſt, they rotting have turned to earth, and the crop thereof every year turning to earth, in proceſs of time ſwells and grows up to a great height: as is manifeſt by divers rivers formerly navigable, now quite grown up. I have ſeen in *Maldon*-moor the

roots of two willow-trees in the bottom of a drain, about a yard deep in mooriſh ground, within three pole of the firm ground, where one might ſee the ſtroke of the axe that felled them to this day: this ground about was excellent good turf, and on a ſudden perfect ſound, and ſo all along for twenty miles long, and in ſome places 30, 40, 50, 60 pole wide, it is good turf-ground: which makes me judge all was a navigable river in times paſt; as alſo the Towns names bordering upon it, as *Temsford-Iſlands*, *Seaford*, *Fleet-haven*, and *Fleetwick*. Secondly, one *William Quayt* of *Maldon*, who yet is or lately was living, plowed up an anchor in a field called *Wickham*-field, adjoyning to the river. Thirdly, there is evident mention of a very ſtrong Caſtle, at a place called *Bedlow*, ſituate upon a firm rock of hard red ſtone hard by this moor-ſide, and now it groweth daily more ſolid by draining, and I perſwade my ſelf will ere long come to be firm paſture: yet I do fully perſwade my ſelf it will ſcarce be ſo profitable then to the owner, as now it is. I remember before cutting of turves was known, a man might have bought in *Weſtoning*-moore in *Bedfordſhire* an acre of meadow the free ſtate for ten ſhillings: nay it was ſo bad, that ſcarce any man knew his own, they ſo little regarded it; yet ſince they have made fourty pounds of an acre, and yet have their ground ſtill, which in 30 or 40 years they make as much more. Now if your bogs be ſo tender, that one cannot go on them, then at the upper part where it firſt riſeth make a large & deep ditch, ſo deep that it may be lower and deeper then the ſprings by a foot or two. This convey ſo, that no water may ſtand in the ditch, ſo that the water of the ſprings may ſo be cut off; making a ditch, though not ſo big, round about: and when it hath drained thus a while that you can go upon it, then dig drains with turf-ſpades aſcue up the hill, as deep as you can, and ſome twenty foot aſunder. And thus (in ſhort ſpace) you may have either good turf-ground, or hop-ground, or Orchard, or paſture at your pleaſure.

CHAP.

CHAP. XXVIII.

To cleanſe a ditch, whether it be full of flaggs, or mud, and not empty out the water.

IF it be full of weeds, get a drag or dung-rake with three teeth, and drag out the weeds: likewiſe for the mud get a mud-pan, which is made of the back of an armour, make a ſocket, and ſlit the little end forked, and flat it, and ſpread it four or ſix inches, and rivet it on the plate, then rivet another round piece, both cloſe by the ſocket, and alſo into the bottom of the plate to ſtrengthen the forks, ſetting it coming toward you as your drag-rake doth. Then, if there be much mud, draw out ſome of it firſt all along the ditch, and when that is hard, ſo that you can go upon it, then draw out more. Thus may you go to it when you will, and leave when you will, without dreſſing you, or damming the water. And thus one man will draw out as much in an hour, as three men will throw out with ſcopets.

CHAP. XXIX.

Of cleanſing a Pond ſix or ſeven pole broad being grown over with a coat of weeds, that it will near bear one, without abating the water.

YOu ſhall for this purpoſe get a boat and a haling-line, good ſtore of drags, cutting-knives of both ſorts, ſuch as they cut mows or hay-ſtacks with, both like ſithes, and ſtabs, alſo wheel-barrows, and half-inch boards of ſix or ſeven foot long apiece. If this coat of weeds be very ſoft, you were beſt to nayl two boards together, with ledges like a door: but if it be any thing hard, let them go ſingle. Then begin with your crones or drags, and cleanſe the out-ſides with them firſt as far as you can reach, and let the barrows carry it away out of your way: then take your boat and ſpret, and for want of a boat take a Brewers cooler, and let two folk go into it, and row your ſelves to the cruſt, and laying

your boards on it, and you ſtanding on them, cut with your ſithe pieces as long and broad as the board, then take up that board as you ſtand on the other, and remove it beyond it, then take you the crones that ſtand on the bank, and having faſtened your haling-line both to the crone and to the ſtale of it, by knitting a knot at the handle-end, let them on the bank draw out thoſe pieces which that they may do the more eaſily, they may level a place about an handful above the water, and pull them thither, and then cut them ſmaller with their ſtabs, and then draw them up.

Now then having thus gone round, and cleared it from the ſides round about, pitch all your crones into one ſide of the core or cruſt, and trie if you can draw it to the bank-ſide (for theſe kind of cores never grow to the bottom, eſpecially if the water be deep), which if you ſo draw it, then may you ſtanding on the bank finiſh all with your crones. But if you cannot move it, then with your ſithe-knife, and help of your dores and boards, you may ſlit it all along, either in the midſt, or as much as you think you can move at once. But now becauſe you muſt move your boards and dores end-long, (which is harder to do then ſide-ways) your beſt way is to have a hook at the end of your haling-ſine, and make a mortes at one end or both of each board, and thus put the hook in the mortes of the hinder door, and raiſing it a little at the end with a couple of chiſils, or ſuch like, draw it till it is entered upon the neather dore, then having a board lie by the ſide of it, ſtay your ſelf on it, till the hinder be drawn along upon the other, and lie foremoſt, and thus may you divide and draw piece after piece till you have finiſhed.

CHAP. XXX.

Of cleanſing of water.

SOmetime you are to bring water to an houſe, but you have none but ſuch as comes from noyſome places: now to purifie ſuch water, if you make a trench of a foot and an half deep

and

and three or four pole long (the longer the better) and fill it a foot deep with hurlock or clunch cut in pieces, as it were for the lime-kill, then fill it an handfull higher with pebles, then fill it up with gravel or earth; it will so purifie it, that it will be fit for brewing, or the pot, or laundressing, or any thing else: if you cannot get hurlock, content your self with pebles. Also it greatly mendeth water in a pumpe or well, first to cleanse out the mud, and then to put in clunch into it. It will likewise purifie the water very much, if you would lay clunch or hurlock as high as the water riseth in your well, in the same form that they use to lay their bricks: so will the water cleanse it self by draining through the body of the clunch.

CHAP. XXXI.

Of quenching an house on fire.

THe Instruments for this purpose (not to speak of the water-squirt, which will throw a whole hogs-head of water to the top of an house at once, for that such are scarce to be had save in some great Towns or Cities) are pikes, spits, mawkins, pike-staves, forks, wet-blankets, ladders, buckets, scopets, pails, &c. and the materials, water, coal-dust, turf-ashes, wood-ashes, sand horse-dung dust, dirt, and in extremity even dreft-grain it self. I know you will think it strange that I should mention pikes, and spits, dust, sand, and ashes; but I speak on often experience, that four men, that know how to use these things, will sooner quench a fire, then 100, that go to work with ladders and buckets to strip houses, and hooks to pull them down. It's a misery to speak it, when the rude multitude are once come together every man will have his own way. If it be a dwelling-house, some will busy themselves to carry out brass, pewter, but their chief aim is at the mony-chest; whilest others wait to take it of them and carrie it away: others perhaps, of more honesty but less wit, will be ripping the house, and so let the fire have the more air to burn the more violently; that, whereas they think thereby to save other

houses,

houſes that are near to it, they uſe (for the moſt part) the onely way to fire them: for the greater the flame is, the more is the danger, and the farther the ſparks of fire will flie. And now, if you will vouchſafe the reading, which is no great labour for you, I ſhall endeavour (God willing) to give you ſuch directions, whereby you may with leaſt loſs, leaſt help, and moſt ſpeedily quench any fire, whereſoever it begins, or howſoever it comes.

The firſt rule is this. If it be in houſe or chimney, do not by any means open any vent to let it out, eſpecially upwards; but rather ſtop all the holes you finde. If the foot of a brick or ſtone-chimney be on fire, diſcharge a piſtoll twice or thrice upon it; ſo ſoot and fire and all falls together. If it be a wooden-chimney, and that all the timber, both ground-ſells, ſtuds, mantle-tree, beams, and all are on fire at once; then firſt with your pike-ſtaff, fork, or ſpit, rub down all the coal, then throw on water, and then aſhes, and all is done. And thus did I my ſelf, all alone, quench a fire at *Weſtoning* in *Bedfordſhire*, where coming that way accidentally; and meeting a woman coming out of a yard wringing her hands and crying, I asked her the reaſon, but ſhe gave me no anſwer; (whether it were for that I was a ſtranger to her, or whether for grief ſhe could not ſpeak, I know not:) but away ſhe runs as faſt as ſhe could. I fearing ſome ſuch matter ran into the yard, but finding the door lockt, and hearing withall a fluttering of fire, I took up an hogs-trough which lay there, and ran againſt the door, and broke it open, and went in; where I found a buck of clothes ſtanding on a tre ſole, and a great many turves under it almoſt burnt out; yet the buck had no hurt, but they had fired the end-groundſels, ſtuds, and all the timber of the chimney. I having been at the Fullers earth-pits, not far from *Oburn*, to ſurvey them, had the foot of my plain-Table in my hand, wherewith I rubbed down all the coals, and then took the buck-cloth by all the four corners, and threw up the aſhes into the chimney, and finding a pail, I ran and fetcht turf-aſhes and water together, and quenched all quite in a quarter of an hour.

hour. All this while not one body came; ſo I was going thence, and as I was going out at the gate, there came near half a ſcore, which ſhe brought out of the field from haying: with theſe I went back again, fearing leſt they ſhould do hurt; ſo preſently ſome of them get ladders, and to pulling off the thatch; but I prevailed with them with much ado to let it alone, and willed them by all means to keep it into the chimney: if they found any holes that it could come out at, to ſtop them up with dirt or cow-dung, and throw dirt or cow-dung on the thatch if they would, and if they ſaw any more fire in the chimney to cover it with a wet blanket.

If it be within a dwelling-houſe, on any ground-ſels, or ſtuds, it is eaſily quenched, doing as afore.

If it be between parget and loft-boards, whereſoever it breaks forth, lay on wet woollen-cloths, hair-cloths, cow-dung, or horſ-dung, with water, aſhes, or ſand.

If it be on the inſide of an houſe either thatched or tiled, between the parget and the roof, cover the out-ſide with wet blankets, hair-cloths, &c. that neither the flame get out, nor air get in. And on the inſide be ſure there be no vent in the parget, but ſtop it with cow-dung, &c.

If it be on the out-ſide of a roof, cover it with wet woollen; or on the top of a mow: and throw no water, but aſhes, ſand, horſ-dung, &c.

If it be on the inſide of the roof of a thatcht houſe, cover the out-ſide with wet cloths as afore. If there be no parget, your onely Inſtrument is a ſcovel, or mawkin, or mop often wetted, and with them ſweep down the fire. And thus I and a boy with a ſcopet, throwing in mault inſtead of aſhes, did at *Tame* quench a thatcht-houſe adjoyning to another in the market-place, which was on fire in eight places at once on the inſide, hard by the eavs; yet being new thatch and hard, it glaunced up to the roof, and broke not out, till it came at the ridge, where were on the out ſide as many people as could ſtand on ladders, ready with water, that no ſooner could a flake of fire peek out of the ridge, but ſtreight they ſaluted it

with a bucket of water: but for all that, ſo ſoon as the fire had broke out at the eavs, (which had been, had not we two aſſwaged it,) they muſt all have ſought a new way down, or elſe have gone through the fire.

If it begin likewiſe upon hemp, or flax, cover it with coverlets, blankets, hair-cloths, &c. and throw on aſhes. If it be on the ſide of a mow, hang wet hair-cloths, or woollen-cloths before it, and cover it at the top, that no flame get out, holding the fore-ſide-cloths as cloſe to it as poſſibly you can. Thus have we ſhewed the ways, how to quench fire in any houſe, where or howſoever it ſhall begin, without pulling down. Now to prevent fire coming from another houſe, cover it with hair-cloths, coverlets &c. and throw on them water'd aſhes, dirt, dung, &c. Alſo if an houſe be pulled down, by no means let it lie there; but, be it what it will, timber, or grain; hay, or ſtraw; quench it throughly, and get carts and away with it into the field, and there ſpread it. I ſaw one at *Burton* in *Bedfordſhire* at one *Francis Woodward's*, who had his barn burnt down, that it kindled again in the carts before they got a furlong from home. And I have heard my Father ſpeak of it often, that there was a Parſonage-barn, with much corn in it, burnt down at *Leighton-Buzzard*, where he was born, and they did not carry it away, but watched it continually; but for eight nights together ſtill about mid-night it broke out again, that they were forced to ring the bells, and to carry all away at laſt, when they had wearied them with watching.

If any ſhall doubt of the efficacie of theſe things, I deſire him to conſider of theſe five things.

Firſt, He ſeeth dayly, that an extinguiſher puts out a candle; yea a candle puts out it ſelf by turning the flame downward: then a blanket on a chimney, or any where elſe, much more.

Secondly, If any doubt the blanket will burn; it may be ſo, if it have holes in it: but they are eaſily ſtopt with throwing on horſe-dung, or dirt. And for both theſe let him try this concluſion: Let him take a woollen rag, and a burning coal either

either of wood, ſea-coal, or turf, (which of all other is hardeſt to be extinguiſhed, and therefore we uſe to take a piece of turf and wet it, and rake it up in the aſhes to keep fire, yet) let him wrap this coal in his cloth, or lay it on the hearth, and cover it cloſe that no air can get in, and your coal quickly dieth.

Thirdly, Ask any ſouldier, and he will tell you, that the beſt way to put out his match is to put it into the mouth of his piece with the coal down-ward.

Fourthly, You may eaſily ſee the effect of duſt, ſand, horſdung, or ſuch like, if ever you ſaw an hearth of char-coal burnt, and quenched.

Fifthly, If a mow ſhould be covered at the top, and not at the end, you will ſay it will burn underneath like an oven: I anſwer, put a whole ſedge-ſheaf into an oven at once, let it be at full fire; ſtop up the oven, and preſently the fire goeth out.

CHAP. XXXII.

Of keeping a fire light all night with a farthing-charge.

I Have before, in the laſt chapter, ſhewed you how to put out fire: now in this I will ſhew you how to keep fire a long while light with a little charge. Suppoſe you dwell in a lone-country-houſe, where one is ſick, and you have but one farthing-candle in the houſe, and borrow you cannot, and you would fain have it laſt burning a whole long-winters-night; then do thus. Cut your candle in two pieces, light one of them; and heat a great pin, and thruſt it into the great end of the candle long-wiſe half the pins length, then fill a pail with water ſo deep that the length of the candle, pin and all, will not reach the bottom, then holding the candle by the light, let it down gently into the water with your fore-finger and thumb, till it comes to the flame, there ſtaying it a while till the water be ſtill, and then take away your hand; ſo ſtill, as the candle burns the flame will raiſe it: and which anſwers

Tallow is a moll matter ſpecifically lighter y^n Water

ſwers the whole buſineſs, that the fire will go no otherways, ſave upward to his own element.

CHAP. XXXIII.

Of laying down of ground for paſture.

OF all ground the beſt to lay for ſward is the black-mould, or ſtrong clay. And although the black-mould be excellent both for Wheat, Barley, and Beanes; yet in the low level ground it is infinitely more commodious for paſture in ſummer; that the three years crop of graſs without any charge at all is more worth then your two crops of grain with all your two years ſeed, your dung, and carriage, and five or ſix plowings, harrowings, rowlings, and weedings. But you will ſay, ground is long in graſſing, and I am but a Tenant, and have but a ſhort time in my leaſe; when I have made it fit for another, my Land-lord will turn me out, or make me pay more rent. This, I confeſs, is ſomething, and in ſome caſes may ſerve for an anſwer: but yet upon this condition thy Land-lord will renew thy leaſe for one and twenty years, (if he be wiſe) and then you are well enough: for whereas you ſay it it long in graſſing, that is remedied with one years charge of arable; for if thou firſt-plow it, and lay it flat, and with as few furrows as may be, about *November*, and then dung it, then plow it again, about the beginning of *March*, ſtill laying it flat, and filling up the furrows; then ſow it with hay-duſt, or chaff-duſt, which every horſ-keeper, if they are ſpoken to about *Michaelmas* before, will (for a trifle) ſave for you on purpoſe. If you harrow in this, you ſhall have a crop of graſs at *Mid-ſummer*, will be worth 30 or 40 ſhillings an acre, and ſtill be better and better. But by all means plow in your dung. I have laid ſome in that manner, and ſome I have dung'd above ground three times, yet this will not be comparable to the other; yet but a furrow of a plow between, and both laid down 40 years ago.

And by no means lay down any ground, that is worn out

of

of heart; for by that means if ever thou get good graſs of it in 40 years, I'le never be truſted, unleſs thou dung it extraordinarily; and yet it will not do. Rather this do; if it be incloſure, take nothing but the mowing crop for divers years together, and ſo doing that crop will be more worth then two whole years crops taken as ordinarily. I ſpeak all this of mine own experience upon my own grounds.

But *I* have often heard of, and in part ſeen another ſort of ſpeedy graſſing, which is this. They ſow their ground with ſeed of claver-graſs, a very ſmall quantitie on an acre, and in ſome places they mow it twice in a year, yet never ſow it but once. Whether they plow it or not, *I* cannot juſtly tell: *I* think not. Thus I have ſeen at *Maddingley* three miles from *Cambridge*, they ſave their common fallow fields till *Midſummer*; and then have an exceeding crop of claver, and then fallow. But whether they ſow for each crop, or whether it be of the nature of Muſtard-ſeed, that need never be ſown but once, though the ground hath lien ſward 40 years before, *I* know not.

But you will ſay, yours perhaps is common-field, if you ſhould lay it ſward, you ſhould lay it for other folks. And what of that? If you have more benefit that way, then you had before, never grudge at it, though others take a part. 2ly, Thou ſhalt take part with others of it, as they do with thee. And in moſt places one acre of ſward hath as good right of common as three, or in ſome places five acres of arable hath. 3ly, There is no doubt but others ſeeing thy good and ſpeedy ſucceſs will ſoon ſecond thee, and then thou ſhalt have as good benefit of his, as he hath of thine.

Ob. But if every one ſhould lay ſward that would, how ſhall we do for bread? *I* anſwer, *I* do not ſay *I* would have every one that liſt ſhould lay down for ſward; but this *I* ſay, *I* would have all ground turn'd to the moſt advantage, firſt of the Common-wealth, then of the owner: I would not have ſuch ground, as will bear two or three load of as good hay as ever beaſt eat, turn'd to arable, when the next acre to it being ſown ſome years hath ſcarce yeelded the ſeed again. Where

an ordinarie acre of paſture is worth 50 ſhillings *per annum*, and the beſt arable not above 8 ſhillings, for as for an acre of ſward, though it be worth but 20 ſhillings to the owner, yet to the Common-wealth it is worth 30 ſhillings the after-paſture, where it is reckoned at a third part of the rent; with us at *Cambridge* far more: and that is not loſt, it doth not vaniſh into air; and though the Maſter get it not, the Common-wealth doth: and how would *Luton* and *Hitching* do for hay, were it not for *Harlington*, *Pullox*-hill, *Gravenhurſt*. Or how would *Cambridge* do, were it not for the Fenns? Yea, I have known that hay hath been carried out of *Bedfordſhire* to *London*, thirty five miles. And I am ſure, that it is an eaſier matter to drive fat cattel an hundred miles, then to carry corn fourty by land. Neither would I have *Chiltern*-ground turned to paſture, becauſe there an acre of arable is more worth then an acre of paſture. Yet certainly it plainly appears by this, that generally there is more want of paſture in *England* then of arable; for that we have daily fat cattel brought out of *Ireland* and *Scotland*, but never any go out; but where grain comes in once, it goes out ten times.

CHAP. XXXIV.

Of the choiſe of a rich ground.

FOr a generall fat ſoil, and ſuch as is good for all things, or at leaſt moſt things, both graſs and grain, (for indeed no ground is fit for all things, *Non omnis fert omnia tellus*) the black ground of a good deep ſtaple, with a mixture of gravel or ſand, is not unworthily commended of the Poet, *Lib.* 3. *Georgic.*

Pinguis item quæ ſit tellus hoc denique pacto
Diſcimus; haud unquam manibus jactata fatiſcit,
Sed picis in morem ad digitos lenteſcit habendo;
Humida majores herbas alit, ipſáque juſto
Lætior ah, nimiùm nè ſit mihi fertilis illa,
Neu ſe prævalidam primis oſtentet ariſtis.

For

For this we commend *Ailes-bury*.

And ſome extoll as highly earth that is of a reddiſh colour; as the ground about *Armagh* in *Ireland*, which (ſome report) hath had no manner of manuring ſince the memory of man. I know ſome ſuch black ground in *Pullox*-hill afore-ſaid, but I know no ſuch red. *Virgil* alſo ſaith, That if you dig a deep hole in the ground, and fill it up again, if you cannot tread in the earth again, then it is rich arable ground, 2. *Georgic.*

---altéque jubebis
In ſolido puteum demitti: omnémque repones
Rurſus humum: & pedibus ſummas æquabis arenas.
Si deerunt; rarum pecorique, & vitibus almis
Aptius uber erit: ſin in ſua poſſe negabunt
Ire loca, & ſcrobibus ſuperabit terra repletis
Spiſſus ager: glebas cunctantes, craſſáque terga
Expetta, & validis terram proſcinde juvencis.

Alſo a ſweet ſmell after the firſt rain, or a drought, or after new plowing, is a token of a rich ſoil. Alſo where thiſtles, nettles, or other weeds grow rank. Alſo where trees grow long and upright. Alſo where fruit, eſpecially pears, are more pleaſant in taſt then in other places: for if a young pear-tree bears pleaſant pears in a good ground, and you remove it into a bad ground, you will think the fruit not to be of the ſame kinde, yet all grounds are not alike for all things:

---Non omnis fert omnia tellus.

And for the moſtpart, thoſe grounds that are moſt barren above, are richeſt within, as ſtone-pits, fullers-earth, lead, coal, tin, ſilver and gold-mines.

Some grounds are fitter for wood, then either for corn or graſs. I have ſeen a ground in *Hartford-ſhire*, that hath been laid two years, where were grown naturally black and rank ſallows all over the ground in tuſſocks, ſome ſix, ſome ſeven foot high, ſo that the crop of wood was more worth then the crop of graſs.

CHAP.

CHAP. XXXV.

Of inriching lean ground.

LEan grounds are either inriched with reſt, or with dunging. As for paſture, if you neither eat nor mow it two or three years, or onely mow it once a year; or if you will eat it, by no means eat it too low, and you will greatly thereby both better the ground, and get a ſpeedier increaſe of the crop; for after it once covers the ground, it grows more in a week, then in ſix weeks before, by reaſon it keeps the ground both hot and moiſt, yet not ſo hot as to be ſcorched with the Sun: therefore be ſure to ſpare ſuch barren grounds by *Candle-maſs* at the furtheſt. As for lean arable, though common-field ground, it is a common thing in divers places, where they have a great deal of lean land that lies far from any Town, to let ſome thereof lie lea ſix or ſeven years; and the longer it lies, the more heart it gets.

As for dunging, the benefit of horſ-dung and cow-dung is every where known in part, yet not to all alike; ſome will not lay it on their land till it is rotten, but will carry it out of their yards, and lay it on dung-hills in the field, either at the lands end, or ſome place near to it, though the land be not then ſown: whereby they make a double labour, and loſe a double benefit of their dung, which they may eaſily finde by this, that a great part of the ſtrength of it goes into the ground it lies upon, as appeareth in this, for if they lay it in ſmall heaps on the land where it ſhould be ſpread, if it lieth long unſpread, let them ſpread it as clean as they can, yet thoſe places will be ranker corn then the reſt. A ſecond benefit which they loſe is the ſtiving upward, which in dry weather ſhould be the onely nouriſhment to the corn. If you pleaſe to try two acres of like land lying together, and carry out twenty loads of horſ-dung about *Mid-ſummer*, that is new-made, as ſuch you may have at an Inn, and lay that on a heap in the field by it ſelf till *February* or *March*, and then fetch twenty loads more of the like, lay theſe twenty on one of the acres, and the heap on

on the other, but let your loads from the Inn be alike, and then tell me which acre is the beſt barley. But though you finde but little difference in the barley-crop, you ſhall finde a vaſt difference in the peaſ-crop. And if you will ſow them three years together, there will be no ſmall odds; for the ſtiving of the dung will be over in two or three years. And this alſo will appear, if you take a load of ſtraw, and lay it in ſome Orchard, where no cattel come, upon planks, boards, or ſtones, and ſpread it ſo that the rain may get into it, and turn it three or four times in a year, and by three years end you will hardly have a quarter of a load of dung left, and that which is left will be turned to earth alſo: yet I deny not but that earth may be better then ordinary.

Alſo ſtreet-earth, eſpecially in Market-towns, where goes ſtore of ſinks from ſtables, kitchens, dairy-houſes, but eſpecially ciſterns for malting. I have known them that have got up all the piſs they could get in a Market-town, and carried it to their land in a tun, and there ſtrewed with good ſucceſs. But if they, that have ſuch convenience for carriage, would but make triall of the water of the ſink of a Cheeſ-preſs, or of ciſtern-water, I doubt not but in ſhort time there would be little of it loſt. *Street-earth.*

And we ſee now how much ſoot is ſet by, which within theſe fifty years men would not ſuffer to be thrown upon the dung-hill, but into the midſt of the ſtreet. *Soot.*

And although, by *Moſes* Law, ſome great offenders were to have their land ſown with ſalt; and likewiſe in *Judges* ix. 45. *Abimelech*, when he took *Sichem*, deſtroyed it, and ſowed it with ſalt; the reaſon was, that it ſhould never bear graſs nor grain. And indeed it is an eaſie matter, either with ſoot, ſalt, pigeon-dung, or piſs, to over-dung and ſpoil all. I have known ſome carry out pigeon-dung in ſacks in *May*, and lay a ſack-full on a heap upon the corn; but they could not gather it up ſo clean, but they kill'd all the corn as far as the heap lay. *Salt.*

I have ſown pigeon-dung in an extream hot and dry year upon *Pigeon-dung.*

upon barley, on an hot and dry land, when at harveſt the barley hath ſcarce peeked out of the hoſe, yet it hath been the beſt in the furlong. Again, I have in a wet year ſown pigeon-dung on ſand, when my crop hath been more worth then the fee-ſimple, or value of the ground.

Folding of land. Land that is folded a little before, or preſently after the ſowing, doth far better then otherwiſe. But herein many men wrong themſelves in ſurfeiting their ſheep in Summer-time, when their fold goes on ſingle-lands, as on roods or half-acres, in laying them ſo thick, that they over-heat one another; thinking that if they have as many hurdles as they had before, that then they lie as thin as they did before; but this I have ſpoken of before in the *firſt Chapter*; where alſo I have ſhewed the diſproportion, and therefore to it I refer you. Yet before I leave this, I muſt add further, that I ſee no reaſon why other countreys may not fold in Winter as well, or rather, then *Oxfordſhire*, or *Buckinghamſhire:* nay, far rather, either upon ſward or arable, eſpecially *Hartfordſhire*, or *Middleſex*, if they will do as they do, that is, winde their hurdles on two ſides with broom, and remove their hay-rack and cratches with their folds. *Hartfordſhire* hath far drier laire, their ſheep more hardy and ſound, and never rotting, more hedges to ſhelter them, and dung infinitely dearer. And if they broom their hurdles to keep them warm, then why not to keep them warm by keeping them together? I never knew ſheep take hurt by lying warm in Winter. If you will not fold your arable, yet fold your ſward; if not your ſward remote from the hedges, yet at leſt your hedg-rows. It is the office of a land-meter, to give the quantity or menſuration; but the office of a Surveyour, to acquint you with all means of melioration.

Rags and Horn-ſhavings. Now we are come to rags and horn-ſhavings. It is almoſt incredible the odds of an acre of the beſt barley in *Hitching*-pariſh fifty years ago, and twenty years ago, and all by buying rags and horn-ſhavings at *London*, carrying up malt, and bringing them down all the year long. As for their rags, they carry them to the land, and lay them on heaps like dung-heaps, but not

not ſo big; then chop them in pieces on a ſtick with a hand-bill, and then plow them in, and theſe and horn-ſhavings endure a long-while, and have ſo mended their ſoil thereby, that whereas about fifty years ago, an acre of their barley was not above three pounds ten, or four pounds the beſt; now about twenty years ago, I was requeſted to meaſure two acres of barley in a field called *Kings-field* in *Hitching*-pariſh that the very crop of them was ſold for nine pounds an acre by the Statute-pole.

Malt-duſt alſo is little inferiour to Pigeon-dung. Alſo lime, five or ſix quarters to an acre. Aſhes of all ſorts. Chalk for all red grounds, both arable and ſward. Scowring of old ditches, good for all white grounds and clay. Alſo marl of ponds, where ſinks of yards run into them; but in a ſpring or running water, though the mud look never ſo black, there is no heart in it, except holpen by land-flouds, becauſe there is no ſalt in it; for ſalt is the ſtrength of all dung: therefore let it alone, unleſs to lay on a white ground, for mixing of earths; for if you lay an hungry gravel on an hungry clunch, *& contrà*, they fertilize each other. *Malt-duſt, Lime, Aſhes, Chalk, &c*

Alſo any ſward plowed up, and thrown on the land, or laid on heaps till it be rotten: or making a dung-hill, and laying *ſtratum ſuper ſtratum*, a laying of ſtreet-earth, and a laying of theſe turves, laying upon laying, till they be rotten, makes an excellent compoſt for many years.

The burning of hawm upon the ground, commonly called *Devonſhiring* (becauſe much uſed in *Devonſhire*) is not unworthily a little extolled of the Poet: *Georgic. lib.* 1.

Sæpe etiam ſteriles incendere profuit agros,
Atque levem ſtipulam crepitantibus urere flammis:
Sive indè occultas vires, & pabula terræ
Pinguia concipiunt: ſive illis omne per ignem
Excoquitur vitium, atque exſudat inutilis humor:
Seu plures calor ille vias, & cæca relaxat
Spiramenta, novas veniat quâ ſuccus in herbas:
Seu durat magis, & venas adſtringit hiantes;

Nè tenues pluviæ, rapidive potentia Solis
Acrior, aut Boreæ penetrabile frigus adurat.

To this give me leave to add a little of mine own experience. About the year $160\frac{3}{8}$, was ſuch a froſt, without ſnow, that it killed all our wheat: one Mr. *How* of *North-Myms* had but two buſhels growing of thirty acres ſown. I ſowed moſt part of mine again with barley in *March*, onely I had one head-land that looked moſt glorioufly, covered green all over, as thick as graſs in a meadow. I thought this might do well enough, I let it alone till mid-*May*, then I began to miſtruſt by the blade, that all were but wild-oats. I digged up a turf as broad as my hand, wherein I found two wheat-corns, but 200 wild-oats, grown to that height all of one depth perfectly upright, as thick as they could ſtand one by another, juſt as letters are ſet in a frame to print a book. How they ſhould come there at all, the Lord knows, much more in that manner. Well then, I ſaw there was no hope of a crop of wheat, and thought it too late to ſow barley, neither had I any left, ſave a little tary-head-corn, that I took & ſteep'd it a day and a night in water of an horſ-dunghill. I ſowed all that head-land; but one quarter of it, which had been troden with horſes turning upon it in wet weather after it was ſown. This barley, when harveſt came, was the firſt I had ripe, clean without tares, or any other ſoil, as thick as it could ſtand, and every way the beſt that ever I had growing: but the wheat not worth the reaping; wherefore I let it ſtand till harveſt was home; but had I mowed it green, it had been the beſt horſmeat of all other, as afterward I found in wild-oats and beans. When harveſt was home, on a fair day, the winde ſitting right, I ſet fire on it: but he that had ſeen that fire, and heard the noiſe, and had not read *Virgil* before, would have ſaid certainly *Virgil* was at that fire before he made his book, and that there he learnt it, or elſe he could never have found out ſuch an Epithete, as ---*Crepitantibus urere flammis*: for whether it was by reaſon of the wild-oats, in every horſfooting made by turning on in wet weather, or otherwiſe, there

there was ſuch a noiſe as if twenty muskets had gone off at once, inſomuch that an herd of cattel being a quarter of a mile off, ſeeing the fire, and hearing the noiſe, as if they had been out of their wits, or rather ſtark mad, ſet up alſo ſuch a running, roaring, bellowing, and howling, that it made me to run as faſt as they, to hear ſuch an hideous noiſe, and the fire ſo violent, the weather being dry, and the whole crop being ſtill there which was very great, and the winde full in one end, and whiſtling, inſomuch that all the ground for two or three and twenty pole long, and a pole and half broad, was all on fire at once: this paſt my skill to quench, neither would all the blankets in the Town have ſerved the turn, if I had had them there. But that this was ſoon out, I think neither the *Sicilian Ætna*, that throweth ſtones ſixty miles nor *Heela* in *Iſeland*, nor *Veſuvius* in *Campania*, that ſends his aſhes more then two hundred miles off; (or, if you will believe *Caſſiodorus*, in the time of *Titus* and *Veſpaſian*, they flew into *Aſia*, *Syria*, and *Egypt*: and laſtly, breaking out again in the year 1632, *Crepitus miliaria centum auditus*: & did you not hear this *crepitus*? certainly it was becauſe either you were deaf, or not near enough) could preſent a greater terrour. But notwithſtanding all this, my wild-oats were not yet killed; and then I was vexed with my ſelf, that I had not mowed them green for horſ-meat: for out of every horſ-footing, contrary to my hopes, I could take up whole yeapſonds, that were never the worſe for the fire, ſave onely their ſmell. Then I filled my hand-kerchief and both my pockets with them, to carry home to my hoggs, hens, pigeons; but not a corn any of them would touch. All this was ſtill worſe and worſe. About *All-Saints*-day following, there came a froſt and a little ſnow, upon that there was ſo many fleſh-crows, that you would have thought that there had been proclamations ſet up in all woods, groves, fields, and yards through the whole land to ſummon them thither, or whether that was their beacon when I burnt it, or no, I know not. Theſe for a fortnight together ſo covered the ground, that you could not chooſe but ſay, it was far blacker then ink: for

this was of a double die, one of black crows, and another of black aſhes. The froſt breaking, thoſe that they had not eaten they trod into the ground with their feet, ſo that by the later end of the moneth, no meadow could be thicker of green graſs, then that was of green-oats. I plowed them in, and by *Candle-maſs* it was green again; I plowed it again, then it lay till the later end of *April*, and was green again; then I ſteeped my ſeed as I did the year before, and ſowed it with barley, and had a very good crop, and ſo killed the wild-oats.

Burning of queach, &c. The burning of queach alſo, in ſome ground, is exceeding profitable. And not onely the ſteeping ſeed in dung-hil water helpeth greatly, but alſo in lime and water, by reaſon that which gives it heart lies cloſe to the root. Some alſo waſh ſeed-wheat and rie in lime and water in the ſeed-leap in the field, and then ſow it, and ſo no crows nor pigeons will ever touch it.

CHAP. XXXVI.

Of planting Willows.

IN ſtead of beetle and ſtake, or crow of iron, make you an augre like a pump-augre, make it after this manner: Make a plate like a peel of a foot or fourteen inches ſquare, well ſteeled, and turn it as an augre is turned; let it have a ſocket like a peel, but four-ſquare, into which put a ſtake of good tough aſh two foot long, and four-ſquare, as the ſocket is, with a bar or hoop of iron about it at the top, to keep it from cleaving: let it be two inches ſquare at the leaſt upward, in which near to the top bore an hole, or elſe make a mortes to put in a croſs piece to turn it by, and to take it out by, then enter it a little with your ſpade, as you do a carpenters wimble with a gouch, and then bore your holes; which in ſtrong clay is an exceeding ſpeedy way. Beſides that, if the ſets be not very great, you will have room enough to ram the moulds down to the bottom.

CHAP.

CHAP. XXXVII.

Of reducing wood-land to ſtatute-meaſure, and ſtatute to wood-land.

I Have ſeverall times meaſured ground by ſtatute, which ſhould have been done by the eighteen-foot pole; but never the contrary. One amongſt the reſt was a cloſe in *Hexton* in *Hartfordſhire*, where three Copy-holders had each of them apart expreſſed in their ſeverall copies, how much by meaſure; but not by what meaſure: thereupon it was taken for granted, that it muſt be ſtatute-meaſure. One of the three had held all in his occupation divers years together, and lying in ſtitches, & no banks between had plowed one amongſt another. A and B would have theirs again. A muſt have ſo much on the Eaſt-ſide, B ſo much on the middle, and C the reſt; for C would neither ſhew his copie, nor yet make known how much he ſhould have. So I laid out each man his ſhare accordingly, and took a plot of the whole. Still it runs in B his minde, that his part was not ſo good as it had been formerly, miſtruſting that I had done him wrong in laying it forth; ſo that he acquainted the Lord of the Mannour with it, who demanded of him by what meaſure he had meaſured it: he anſwered by the ſtatute-pole; Then, quoth the Lord, there is the errour, the cuſtome is eighteen foot, and was the meaſure taken in *Henry* the *eight* his time. This being known and reduced, C ſhewed his copie, and there was not a pole difference in the whole thing: ſo I gave them direction to alter it without going to the ground. To do this there are ſeverall ways. Firſt a ſtatute-pole is ſixteen feet and an half, or 33 half-foot long, therefore 33 half-feet ſquare is 1089 ſquare half-feet in a ſtatute-pole: but in an eighteen-foot pole, which is 36 half-feet ſquare, are 1296: ſo then if you multiply your ſtatute-poles by 1089, and divide the product by 1296, you have the number of eighteen-foot poles, which divided by 40 gives you the roods, and *vice verſâ*. And thus ſix acres of ſtatute, which

is

is 960 poles, multiply'd by 1089 makes 1045440, and that divided by 1296 gives 806 $\frac{864}{1296}$ or $\frac{2}{3}$ which is five acres ſix pole $\frac{2}{3}$ of the 18 foot.

Likewiſe five acres of 18 foot is 800 pole, that multiply'd by 1296 produceth 1036800, which divided by 1089, quotient 952 $\frac{12}{1089}$ pole, that is 5 acres, 3 rood, 32 pole. And this is the beſt way. So that the analogy is thus.

As 1089. 1296 :: 800. 18 foot pole to 956. $\frac{12}{1089}$, *id eſt*, 5 acres, 3 roods, 32 pole $\frac{12}{1089}$. And as 1296. 1089 :: 800 ſtatute, to 672 $\frac{2}{9}$, *id eſt*, 4 acres, 3 roods, 32 poles $\frac{2}{9}$. And this is your beſt way: and thus may you do with all other poles.

Another way is, if upon your ſcale you have two ſcales, one of 11 in the inch and another of 12: if you lay down ſtatute-meaſure by the ſcale of 12, and then meaſure the ſame plot by the ſcale of 11, it gives you the wood-land meaſure, and likewiſe on the contrary.

CHAP. XXXVIII.

To finde any ſcale that a plot is made by, the content being known.

SUppoſe any ſcale, as 10, and meaſure it by that; now if by meaſuring it by the ſcale of 10, it comes to but 23 acres 82 parts: but it is truely 34 acres, 31 parts; therefore finde a mean proportional between theſe two; which, becauſe the work is ſomewhat difficult, I will therefore ſhew you the manner of it.

Firſt multiply 32. 82. by 34 31. as here it is ſet down: ſo you ſee it produceth 817 | 2642. And becauſe there are four figures in the Fractions of the two Factours; therfore there

34.	31.
23.	82.
68.	62.

are

are alſo four in the product; ſo the whole number is 817 and 2642, the Fraction, the ſquare-root is 28 ⌊ 59. which is the mean proportional deſired; then ſay, As the leſſer of the two numbers, *viz.* 23, 82. is to your mean proportional 28. 59: ſo is your ſuppoſed ſcale to 12. the true ſcale, as 23. 82. 28. 59 :: 10. 12. See the work.

27. 44. 8.
102. 93.
686. 2.

817 ⌊ 2642
4 (28 ⌊ 58
417
48
384

28 ⌊ 59
10
28590 (12
2382
4770
2382
4764
6

3326
565
2825
50142
5708
45664
4478

But becauſe there is too much difficultie to finde it this way, and ſo little by the line of numbers, and ſo ſoon done, and is exact enough; therefore by it divide the diſtance between 23, 82, and 34, 31. into two equall parts, and the compaſſes will fall at 28, 59. then becauſe 28, 59. is more then 23, 82. therefore ſet one foot in 10, and turn the other upward; it will fall at 12, the ſcale deſired.

CHAP. XXXIX.

Of making an Index *or Table, whereby readily to finde out any ground, that ever you have meaſured, and to tell the quantity of them an hundred years after, and draw a plot of them without going again into the field.*

I Shewed before (in *Chap.* 2.) the manner of keeping your field-book; by help of that, and this, you may readily obtein your deſire.

All the field-books, that ever you fill with notes, page

them all; writing at the top of each page the name of the Pariſhes, or Pariſh, wherein the land lieth conteined in that page: and, at every beginning of a new man, ſet down his name; and likewiſe at the beginning of every new field, furlong, or parcell in a furlong, ſet down the name of the cloſe, field, furlong, or parcell. Alſo write on the cover of your firſt book, A; on the ſecond, B; on the third, C; &c. Then reſerve four and twenty pages at the end of your firſt book, A; which ſhall not be paged, or elſe make a little book by it ſelf: and on the cover thereof write *INDEX*, and on the top of each page, write A, B, C, &c. in *Alphabetical* order. Then under each ſeverall letter write: firſt the Towns name beginning with that letter; ſecondly, The mans name, for whom you meaſured; thirdly, The books name, in which you wrote it; and fourthly, The pages: either all of them, or, at leaſt, the firſt and laſt. And whereas you may think this way will not be ſo beneficial to you, as to go meaſure it again; for that you may do as you ſee good: you need not finde it, unleſs you will. Beſides that, you deſerve pay both for ſurveying, plotting, and notes; as if you had meaſured it. And if you will meaſure it again, theſe notes will do you no hurt. See an example:

P

Purton. W. Norton. lib. *C.* pag. 31, 32, 33, 34.
Panchurch. Rob. Audley. lib. *B.* pag. 64. *ad* 76.
Putford. Tho. Dennie. lib. *K.* pag. 97. *ad finem.*

Refer

Refer this following to pag. 85. line 13.

But if you would bring water to your houſe from a conduit, where you deſire to place a cock as high as you can, and that without Inſtruments: Firſt, begin at the conduit, and dig a trench near a foot deep there; but as you go farther off, let it be ſtill ſhallower for five or ſix pole in length, more or leſs, according to the fall of the ground; ſo that the water may but juſt follow you, and when it begins to run over, there ſtay it, and begin a new depth as afore: but be ſure the fall of it be down-right like a ſtair, and ſo go on till you come where you would be: then add the fall at the conduit, and all your ſtairs together; and ſo high may you ſet your cock above the level of your trench.

FINIS.

¶ An Appendix to my *Faithfull Surveyour.*

WE have, in the book it ſelf, ſpoken of meaſuring ſuch things, as are meaſured by obſerving Inſtruments, as the Pandoron, plain-Table, Quadrant, Quadrat, Theodelete, Circumferentor, &c, *viz.* of meaſuring of land, taking of Altitudes and Diſtances, taken by the chain: here we will ſpeak of ſuch *ſuperficies* as are done by a two-foot-rule, as board, glaſs, pavement, wainſcot; and of ſolid, as ſtone and timber: forbearing thoſe things, that ſeldome, or never, come in queſtion; as globes, regular bodies, and the like. Firſt, Becauſe land-meaſure and thoſe ſeldome meet together in one man; Secondly, Neither would I have the book to be of two big a price; and Thirdly, Becauſe my little time I have, hath need to be ſpent to the beſt advantage for the common good.

CHAP. I.

Of making the Rule.

FIrſt, I would have the Rule, (whether it be of box, or of braſs; whether joynted in the middle, or ſtreight out.) to be juſt two-foot-long by ſome ſtandard of braſs, kept by the *Clerk of the Market* and not, as I have ſeen ſome; that have been half an inch too long. Let it be an inch and an half broad at the leaſt, and a third part of an inch thick with a ſquare ſtroke ſtruck round about it juſt in the middle of the length thereof. Let one edge be beſild off: which ſerves that if you have occaſion to draw lines with a pen, if you turn that ſide downward, you need not fear blotting: if your rule chance to be blackt with inke, if you rubb it well with ſorrel, that will fetch it out. Through the midſt of this beſill ſtrike a Gage-ſtroke: an another along the midſt of the other edge:

divide

divide the reſt of this ſide, beſide the beſill, into eight equall parts with ſeaven Gage-ſtrokes. In the 4 next columnes ſave one to the beſill, you may place all the under-meaſure of this Table of board-meaſure following, which will not fall in a ſcale upon the rule, *viz.* all inches, halves, and quarters from one inch to ſix, or if you will to ten inches, in ſmall ſpaces the inches of the breadth of the board, in the column next ſave one to the beſill: the feet required to a foot foreward at the breadth in the next: the odd inches in the third: and the *Centeſmes* in the fourth. And adjoyning to this Table toward the middle of the Rule, in the firſt of thoſe four columnes ſet one inch divided into ten equall parts, and each of thoſe into halves, and each of thoſe halves into five; or ſuppoſe them ſo divided: ſo is it divided into 100 parts or *Centeſmes*: from which inch you ſhall take off all your *Centeſmes* with your compaſſes, that are to be ſet in any of your ſcales.

For making the ſcale of board-meaſure.

Before you can make this ſcale, you muſt have one column, on the otherſide the Rule next the beſill, parted into three ſmall parts with Gage-ſtrokes, and divided in the middle of the length of the rule into two equall parts or feet: whereof divide one of them into ten equall parts, and each of them into ten more, and each of them ſuppoſe at leaſt to be divided into ten other; ſo ſhall that foot be dvided into 1000. and this *Gunther* calleth foot meaſure: which muſt be reckoned both wayes, firſt from the beginning of the rule to the middle, thus, 1, 2, 3, &c. and backward again, and thus, 11, 12, 13, &c. and becauſe the other foot makes ten of theſe inches, and theſe ten make twelve of them, therefore divide the other foot into twelve equall parts or inches, and each inch into eight parts, and number it from the end toward the middle with 1, 2, 3, 4, &c. but from the middle to the end with 13, 14, 15, &c. and this he calleth inch-meaſure. By help of this inch-line and the inch aforeſaid, and by help of your Tables for board and timber-meaſure, are made your ſcales for board and timber-meaſure. And this Table of board-meaſure

is thus made: Firſt, for all whole inches divide 144 by the inches of the breadth, and you have the inches forward to a foot. If any thing remain after diviſion, it is the Numerator of a common Fraction, whoſe Denominator is the Diviſor; to which remain annex two ciphers on the right hand, and divide again by the ſame Diviſor, and you have the *Centeſme* deſired. *Example.*

Let a board be ſeven inches broad, I deſire to know how many inches forward makes a foot. Divide 144 by ſeven, it gives twenty inches; or one foot eight inches $\frac{4}{7}$. Now to bring $\frac{4}{7}$ into *centeſmes*, annex two ciphers to the remain four, it makes 400: which divide again by ſeven, it gives $_{1}\frac{12}{100}$. But for half-inches reduce the breadth into an improper Fraction, as $6\frac{1}{2}$ is $\frac{13}{2}$; then multiply 144 by the Denominator 2, it gives 288: ſo that you muſt always divide 288 by the Numerator, or number of half-inches of the breadth of the board, which is 13; ſo have you 22, or one foot, ten inches, 15 *centeſmes*. But if your breadth be an odd quarter, or three quarters: Firſt, reduce it into quarters, and divide 576 by it: ſo $6\frac{1}{4}$ is 27 quarters, therefore divide 576 by 27, it gives 21 inches, or one foot, nine inches, $_{27}\frac{2}{7}$, or 33 *centeſmes*. The Table followeth.

A Table ſhewing how many feet, inches, and centeſmes *of inches forward are required to make a foot of board meaſure at all breadths, both whole inches, half-inches, quarters, and three-quarters, from one inch in breadth to* 36 *inches.*

Quar. Board.	feet.	inch.	cent.	Quart.	feet.	inch.	cent.	Qu	inch.	cent.	quar.	inch.	cent.
1 0	12	0	0	8 0	1	6	0	15	9	60	22	6	55
1	9	7	20	1	1	5	46	1	9	44	1	6	47
2	8	0	0	2	1	4	94	2	9	29	2	6	40
3	6	10	29	3	1	4	46	3	9	14	3	6	33
2 0	6	0	0	9 0	1	4	0	16	9	0	23	6	26
1	5	4	0	1	1	3	56	1	8	87	1	6	19
2	4	9	60	2	1	3	16	2	8	73	2	6	13
3	4	4	36	3	1	2	77	3	8	57	3	6	6
3 0	4	0	0	10 0	1	2	40	17	8	41	24	6	0
1	3	8	31	1	1	2	5	1	8	32	1	5	94
2	3	5	15	2	1	1	76	2	8	22	2	5	88
3	3	2	40	3	1	1	35	3	8	12	3	5	82
4 0	3	0	0	11 0	1	1	9	18	8	0	25	5	76
1	2	9	88	1	1	0	80	1	7	81	1	5	70
2	2	8	0	2	1	0	51	2	7	78	2	5	65
3	2	6	31	3	1	0	25	3	7	68	3	5	59
5 0	2	4	80	12 0	1	0	0	19	7	58	26	5	54
1	2	3	41	1	0	11	76	1	7	48	1	5	48
2	2	2	18	2	0	11	52	2	7	39	2	5	43
3	2	1	4	3	0	11	29	3	7	29	3	5	38
				Qu.	*Inch.*	*Cent.*							
6 0	2	0	0	13 0	11	8		20	7	20	27	5	33
1	1	11	4	1	10	87		1	7	11	1	5	28
2	1	10	15	2	10	67		2	7	2	2	5	24
3	1	9	33	3	10	46		3	6	94	3	5	19
7 0	1	8	57	14	10	29		21	6	86	28	5	14
1	1	7	86	1	10	11		1	6	78	1	5	1
2	1	7	2	2	9	93		2	6	69	2	5	5
3	1	6	58	3	9	76		3	6	62	3	5	1

Q.	I.	C.	Q.	I.	C.	Q.	I.	C.	Q.	I.	C.
29	4	97	31	4	65	33	4	36	35	4	12
1	4	93	1	4	61	1	4	33	1	4	9
2	4	89	2	4	58	2	4	30	2	4	6
3	4	84	3	4	54	3	4	27	3	4	3
30	4	80	32	4	50	34	4	24	36	4	0
1	4	76	1	4	46	1	4	21			
2	4	73	2	4	43	2	4	18			
3	4	69	3	4	39	3	4	15			

Now to place this Table upon the rule, divide the ſecond, third, fourth, and fifth columns next to the beſill, at one end into ſmall ſquares that may hold two figures a piece, in which ſet over-moſt the inches of the breadth, in the ſecond the feet required in length, at each inch, half inch, and quartern. In the next the odd inches, and in the next the odd centeſmes: and this you muſt do to ſix inches, you may do it to ten inches if you will. Then at the end of ten inches, ſet one inch divided into ten equal parts, and each of them into halves, and ſuppoſe each half into five, ſo will it be ſuppoſed to be divided into an hundred parts, as before. Then from ſix inches to 36 you ſhall ſet all in the column next the beſill, with ſmall ſtrokes, after this manner: Firſt, I begin with ſix inches and a quarter, to which I finde in the Table there belongeth one foot, eleven inches, four centeſmes, that is eleven inches, four centeſmes from the middle croſs ſtroke of the rule. But becauſe my compaſſes will not reach ſo far, I onely take 56 centeſmes from the former inch, which makes it juſt two foot from the ſame end, which I ſet the under meaſure at.

Another example let be $9\frac{1}{4}$, for which I finde in the Table one foot, three inches, 56 centeſmes. Firſt, I take with my compaſſes 56 centeſmes from my inch of centeſmes, and prick it down upon a line upon a paper. Alſo with my compaſſes I take

take three inches in the foot-line of inch-meaſure on the other ſide of the Rule: ſet that diſtance alſo on the paper at the end of the 56 *Centeſme* in the ſame line; then take with your compaſſes the whole length of both, ſet one foot in the middle-croſs-line of the Rule, and in the ſaid ſcale, and the other toward the beginning of the Rule, and it gives the length correſpondent to nine inches and $\frac{1}{4}$, from the ſtroke to the end of the Rule. Thus do with all the reſt; marking each whole inch with its proper number to 24, alſo 30, and 36.

And now, before we proceed to ſhew you the making of the Table of timber-meaſure, we will firſt ſhew the meaſure of boards.

CHAP. II.

Of meaſuring of boards with the Rule.

THere are divers ways of meaſuring of boards: of which the fundamental way is this; 12 inches in length, and 12 in breadth, that is twelve times twelve, or twelve inches ſquare, which is 144 inches, make a foot of board: therefore multiply the inches of the length of the board by the inches of the breadth, and divide the product by 144, you have the content in feet. If any thing remain, divide it by twelve, it gives the odd inches, or twelve parts of a foot: for an inch is the twelfth part of a foot, let the foot be what it will. *Example.*

Let a board be 13 foot five inches long, that is 162 inches long, and nine and an half broad, theſe multiplied give 1529 and an half, which divided by 144, give ten foot, & 89 ſquare inches and $\frac{1}{2}$ remains, which divided by 12 is 7 $\frac{1}{2}$ *ferè* inches of board. Secondly, If you multiply the length in feet, 13 feet 5 inches, by the breadth in inches 9 $\frac{1}{2}$: firſt, 9 inches by 13 foot, is 9 foot 9 inches; & half of 13 is 6 $\frac{1}{2}$, and 6 ſquare inches; and 9 times 5 inches is 45 ſquare inches; and half five inches is two and an half ſquare inches. Firſt then, add all your inches together, 45, 6 and 2 $\frac{1}{2}$ make 53 and $\frac{1}{2}$, which divided by 12, gives 4 board inches, and 5 $\frac{1}{2}$ ſquare inches, or half a board

inch *ferè*. Now add theſe 4 inches to 9 and 6 inches, they make 19 inches, that is, one foot, ſeven inches, to which add 9 foot, it gives ten foot, ſeven inches ½ *ferè*, juſt as afore: and both thoſe ways are performed by any common Rule that hath no board-meaſure on it. Hence then is diſcovered this errour, that if a board be nine inches broad, to take 15 inches forward to make a foot, that is ſo much more then twelve, as nine is leſs, whereas our Table ſaith you muſt take 16, is a falſe way: for nine times 15 is but 135, which wants nine ſquare inches of 144, and is always the ſquare number of half the difference of nine and 15 equally diſtant from 12, whoſe ſquare is 9. So likewiſe 8 and 16 being multiplied make 124, which wants 16 of 144: and becauſe they are equidiſtant from 12, and their half difference is 4, therefore their product is leſs by ſixteen, the ſquare number of four, then the ſquare of twelve.

3. A third way of meaſuring board is by this rule, Meaſure the breadth of the board; if it be leſs then ſix inches, your Table of under-meaſure will ſhew you how much forward you muſt take to a foot forward. If it be broader, and under 36 inches, then the ſtrokes on your ſcale give it.

4. Some meaſure all the breadths of the boards with a line, then ſtretch the length on a block, and ſo meaſure the breadths of all the ſtock at once, and then meaſure the length of a board, then multiply the length in feet and parts, by the breadth in feet and parts: So ſuppoſe the breadth of all the boards is ten foot, nine inches, and the length 154 inches, inſtead of nine inches, I take ½ ¼ of a foot, and inſtead of four inches I take ⅓ or ¼ one inch, and the work will be thus, and it makes 164 feet ¾, 1 inch and an half.

	15. 4. 1.
	10. 2. 4.
	150.
	2. 2.
	248.
	7. 248.
	3. 24.
	164. 2. 4. 1. 2.

And this is a very good way in caſe a block be hewn eight-ſquare, before it be ſawn: which if it be fit for boards, it is pitty it ſhould be hewn any other way; ſo will it be no loſs of timber, the boards will be all ſtreight-edged. If it be ſold in timber, and meaſured as eight-ſquare,

(as ſhall be ſhewn) there will be no loſs either to buyer or ſeller.

CHAP. III.

Of making of a Table of timber-meaſure for ſquare timber, to make the ſcale of ſquare timber-meaſure by: as alſo the under-meaſure.

Firſt know that a foot of timber is twelve inches every way breadth, length and thickneſs, and therefore conteineth 1728 ſquare inches, for 12 times 12 is 144, that is, a foot of board or a *ſuperficies*, and twelve foot of board make 1728 inches; therefore to proceed to the Table. Firſt, For whole inches: ſquare the ſquare of the piece, that is, multiply the ſquare by it ſelf, and by that product divide 1728. *Example.* Suppoſe the piece be 8 inches ſquare, the ſquare of 8 is 64, by which divide 1728, it gives 27 inches, or two foot, three inches. But if you have odd half-inches, then you muſt reduce as before all your inches into half-inches, or an improper Fraction, by whoſe Denominator (which will always be 4) multiply 1728, it gives 6912, which muſt always be divided by the Numerator of the Fraction. Suppoſe the ſquare given be 6 $\frac{1}{2}$, that ſquared is 42 $\frac{1}{4}$ which reduced is 169 quarters; by which 169 divide 6912, it gives 46 inches, or 3 foot 4 inches ninety *Centeſmes*. Again if the ſquare be of odd quarterns or $\frac{1}{4}$ you muſt work as before, and then your divident will be 16 times 1728, that is, 27648. *Example.* Let your ſquare be 6 $\frac{1}{4}$, that ſquared is 45 & 9 ſixteenths: which reduced into 16 parts by multiplying 45 by 16 and adding 9, it gives 729 ſixteenths. Therefore divide 27648 by 729 it gives 37 inches, or 3 foot, 1 inch, 92 *Centeſmes*.

Here followeth the Table of timber-meaſure.

Inch squar.	feet.	inch.	cen.	inch squar.	feet.	inc.	cent.	Inc.	Inc.	C.	Inc.	Inc.	C.
1	0	144	0 0	8	0	2	3 0	15	7	68	122	3	57
	1	92	1 92		1	2	1 39	1	7	43	1	3	49
	2	64	0 0		2	1	11 91	2	7	19	2	3	41
	3	47	0 24		3	1	10 57	3	6	97	3	3	34
2	0	36	0 0	9	0	1	9 33	16	6	76	23	3	27
	1	8	5 33		1	1	8 19	1	6	54	1	3	20
	2	23	0 48		2	1	7 14	2	6	35	2	3	13
	3	19	0 60		3	1	6 25	3	6	16	3	3	6
3	0	16	0 0	10		1	5 28	17	5	98	24	3	0
	1	13	7 55		1	1	4 44	1	5	81	1	2	94
	2	11	9 6		2	1	3 67	2	5	64	2	2	88
	3	10	2 88		3	1	2 95	3	5	48	3	2	82
4	0	9	0 0	11		1	2 28	18	5	33	25	2	76
	1	7	11 67		1	1	1 65	1	5	19	1	2	71
	2	7	1 33		2	1	1 6	2	5	5	2	2	66
	3	6	4 75		3	1	0 51	3	4	91	3	2	61
				Inch.	*Inc.*	*C.*		*In.*	*In.*	*C.*	*In.*	*In.*	*C.*
5	0	5	9 12	12	12	0		19	4	78	26	2	56
	1	5	2 69		1	11 51		1	4	66	1	2	51
	2	4	9 12		2	11 6		2	4	55	2	2	46
	3	4	4 26		3	10 63		3	4	43	3	2	41
6	0	4	0 0	13		10 29		20	4	32	27	2	37
	1	3	8 23		1	9 82		1	4	21	1	2	33
	2	3	4 89		2	9 48		2	4	11	2	2	29
	3	3	1 92		3	9 14		3	4	1	3	2	25
7	0	2	11 27	14		8 82		21	3	92	28	2	21
	1	2	8 88		1	8 52		1	3	83	1	2	17
	2	2	6 72		2	8 22		2	3	74	2	2	13
	3	2	4 77		3	7 90		3	3	66	3	2	9

In.	In.	C.	In.	In.	C.	In.	In.	C.	In.	In.	C.
29	2	6	31	1	80	33	1	59	35	1	41
1	2	2	1	1	77	1	1	56	1	1	39
2	1	99	2	1	75	2	1	54	2	1	37
3	1	95	3	1	72	3	1	52	3	1	35
30	1	92	32	1	69	34	1	49	36	1	33
1	1	89	1	1	66	1	1	47			
2	1	86	2	1	64	2	1	45			
3	1	83	3	1	61	3	1	43			

To place this Table on the Rule.

Begin at the other end of the Rule taking thoſe 4 columns next the thick edge ſave one, and divide them into little ſpaces, as you did for board-meaſure, ſetting on them all the under meaſure to 8 inches and an half ſquare, yet you may do it to 12 inches, if you will; ſetting the ſquare inches of the block in that column next ſave one to the edge: then the feet required to make a foot forward in the next: then the odd inches in the next to that, and the *Centeſmes* in the laſt of the 4. Then from 8 and ½ to 36 you may take off your inches from your line of inch-meaſure, and your *Centeſmes* from your inch of *Centeſmes*, as you did in board-meaſure, and place it backward or forward, according as it ſhall be more or leſs then a foot.

CHAP. IIII.

Of meaſuring ſolids, as ſtone, timber, &c. and firſt of ſquare timber.

FOr meaſuring all kind of ſolids the fundamental or generall way is to multiply the inches of the breadth by the inches of the depth, and that product by the inches of the length, and divide the laſt product by 1728. This is ſo plain, it needs no example: and this is the beſt way for ſtone of all other.

2. A ſecond way of meaſuring ſquare timber is by this Ruler. Having the ſquare of the piece given look on the Rule, and ſee how often you finde the length required at that ſquare between that and the end of the Rule in the length of the block, ſo many foot of timber is in that block.

To finde the true ſquare of a piece broader one way then another.

But to finde the true ſquare of the piece, multiply the breadth by the depth, and from the product extract the ſquare-root.

As let the breadth be eight, and the depth 14, theſe multiplyed make 112, whoſe ſquare root is 10 $\frac{12}{21}$, according to which ſquare you muſt meaſure the piece. Which diſproveth a common errour; which is this, To add both ſides together, and to take $\frac{1}{2}$ thereof for the ſquare: for ſo 8 and 14 make 22, the half thereof is 11. And although there ſeemes but ſmall difference, *viz.* leſs then $\frac{1}{2}$ an inch between their numbers or roots 10 $\frac{12}{21}$ and 11: yet between their ſquares there is no leſs then 9 inches difference, for 11 times 11 is 131, but 8 times 14 is but 112.

3. Now therefore becauſe every Carpenter cannot extract the ſquare-root, and to them that can do it, it is but a ſlow way: and thirdly we never ſet any ſcales of timber-meaſure upon Rules, but for inches, halves and quarters: take this for the beſt way of all other, where there is ſuch difference of the ſides meaſure it firſt that falſe way, then take out of it always a ſquare piece of $\frac{1}{2}$ the difference of the ſides. quite through the block; ſo in our example 8 and 14, their difference is 6, the $\frac{1}{2}$ thereof is 3: therefore take a piece of 3 inches ſquare through the length of the block, for that 3 ſquared gives 9. which is the difference between the ſquare of it and the rectangle of 8 times 14.

CHAP.

CHAP. V.

Of round timber.

BEcauſe to every circle there belongeth 3 ſquares, firſt the ſquare without the circle, or the ſquare of the diameter; ſecondly, the ſquare equal to the circle, not in Peripherie, but in the *area*; for if the *area* of a circle of a mile round, and a mile about in a ſquare be compared, we ſhall finde the ſquare to contain juſt 40 acres, whereas the circle of the ſame Peripherie containeth 50 acres, 3 roods, 25 poles $\frac{1}{11}$; and thirdly the ſide of the ſquare within the circle: therefore we will firſt ſhew the manner of making theſe 4 ſcales, and then the meaſuring of round timber: yet before we ſhew the making of them our beſt way is to take *Virgil's* advice, and to do as he doth with his Bees.

Principio ſedes apibus ſtatióque petenda.

So before we ſhew the making of them we will firſt finde out a ſeat for each of them, and then the making of them one after each other. Firſt, in the beginning of the firſt chapter we ſhewed that we would have one of the edges on one ſide beſild off: and the reſt of that ſide divided length wiſe into eight equal columns with 7 Gage-ſtrokes upon the beſill, $\frac{1}{3}$ the length of the Rule, you may ſet a ſcale of 20 in the inch dividing each inch into halves and quarters. Numbring each half-inch with 10, 20, 30, &c. ſave that half-inch next the beginning, which muſt not be accounted for any of the tens: but that muſt be divided into ten equall parts by it ſelf, to take the odd inches above even ones, that any round block or circle is about.

Beſides this, you have three other ſcales that are for round meaſure, that ſhew the three ſquares belonging to the circle: and any of theſe four being known, all the reſt are known onely by taking the number thereof upon its proper ſcale with your compaſſes, and apply that diſtance to the ſcale proper to the thing deſired: and theſe three ſcales for theſe ſquares are

one

one for the Diameter, or ſide of a ſquare without the circle, and that each ſide thereof toucheth the circle. Another is the ſide of a ſquare within the circle, or of the chords of 90 degr. and the other is a ſide of a ſquare, whoſe content is equal to the content of a circle. For *Example*. Let a block be girded about with a nealed wyer, and then that wyer laid along upon the block, being found to be 88 inches, I ſet one foot of the compaſſes in 80 of the ſaid circle ſcale, and the other foot in 8 of thoſe 10 odd parts next the beginning of the Rule, reckoned from ten upward, being the contrary way to the other 80. If then you deſire to know the Diameter of the circle, or ſide of the ſquare including the circle, you ſhall finde it juſt 28 inches, by ſetting one foot of the compaſſes in 25 of the Diameter ſcale, and the other will fall in three odd parts, which added make 28: for all theſe three laſt ſcales muſt be divided into fives, and numbred with 5, 10, 15, &c. and five odd ones above, at the beginning. Likewiſe if you apply the ſame wideneſs of the compaſſes to the ſcale of the ſquare within the circle, that is, to the ſquare, that a block being round will be, being hewed juſt to the four edges; then ſet one foot of the compaſſes in one of thoſe great diviſions by fives, ſo that the other may fall amongſt the odd ſmall diviſions, and it gives you 19¼ *feré*.

And laſtly, if you apply the ſame wideneſs of the compaſſes to the ſcale for the ſquare equal, ſetting one foot in the great diviſions, ſo that the other may fall in the five odd ſmall ones, it gives 24 and about ⅘.

And in like manner if any of the other three ſcales be given, as if the Diameter 14 be given; if you take 14 upon the Diameter, and carry that to the circle, it gives 44; if to the ſquare equal, it gives about 12⅕, and ſo of the reſt.

CHAP.

CHAP. VI.

Of the proof of theſe ſcales by Arithmetical calculation.

FIrſt, for the circle-ſcale, that needs no proof, ſo that it be truly divided: for that is the baſis, on which the other are built; or ſcale, by which they are made.

Secondly, For the Diameter *Archimedes* gives this rule, Multiply the Circumference by ſeven, and the product divide by 22, ſo have you the Diameter: ſo on the contrary. Thus our circle 88, multiplied by ſeven, gives 616, which divide by 22, quoteth juſt 28, as afore.

Thirdly, For the ſquare within the circle this is the rule. The ſquare without the circle is double in content to the ſquare within. Or thus, The content of the ſquare within the circle is to the content of the circle as 7 to 11: Firſt, therefore by the content of the ſquare without, we found the Diameter, or ſide of the ſquare to be 28, that ſquared or multiplied by it ſelf is 784, the content thereof. Therefore the content of the ſquare within is but $\frac{1}{2}$ 784, that is, 392. whoſe ſquare-root is 19 $\frac{11}{39}$, as afore. Secondly, by the content of the circle: for which *Archimedes* ſaith, half the Diameter multiplied by half the Circumference gives the content, ſo 44, the half of the Circumference, multiplied by half the Diameter 14, gives 616, the content of the circle. This therefore multiplied by ſeven, makes 4312, which divided by eleven gives 392, juſt as afore.

Fourthly, For the ſquare equal to the circle, having by this laſt rule found the content of the circle to be 616, we need but extract the ſquare-root thereof, which is 24 $\frac{40}{49}$, which doth diſcover a moſt monſtrous, and a moſt groſs errour in meaſuring round timber, of which hereafter.

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CHAP. VII.

Shewing the manner of placing theſe upon the Rule.

FIrſt, To ſet out the Diameter, you may take the nether part of the third column of the beſil'd ſide, to ſet it on from the middle ſquare ſtroke of the Rule. Then *Gunther* (in his *Uſe of the line of numbers in broad-meaſure, Prop.* 11.) hath this proportion. Having the Circumference of a circle, to finde the Diameter: As 3143 to 1000, ſo is the Circumference, ſuppoſe it 47⌊13 to the Diameter 15: ſo that if you take 47⌊13 in your circle-ſcale, and ſet in that column from the middle ſquare downward, ſo ſhall you ſet out 15 in that diſtance, run that diſtance as oft as you can to the bottom of the Rule, which will be 4 times more, divide each of them into 3 equal parts, and the uppermoſt third into 5 equal, and number all the other great parts, ſave that with 5, 10, 15, &c. or if you will you may double 47⌊13, that is 94, 26, and take it from the circle-ſcale, ſet it there they will be 30, then half it, and they will be 15, then third it into fives.

2. To finde how to proportion the ſquare within the circle by the Diameter. Let the Diameter be the *Radius* 1000, then will the chord of 90 degrees, which is the ſide of the ſquare included, be the natural ſine of half 90: *viz.* 45 degrees, the ſine whereof is 707, therefore then becauſe I would divide my ſcale into even ſines, if therefore I take 7 times 5, that is 35, the proportion will be 707. 1000 :: 35. 49⌊50. or 49½: therefore if you take 49½ on the Diameter, and ſet it on the ſcale of chords, and divide it into 7 equal parts, and that part next the end into 5 ſmall parts, numbring all but that with 5, 10, 15, &c. you have your ſcale of chords or ſquare within the circle. Or (if you think it troubleſome to divide it into 7 equal parts) you may take 6 times 5, that is 30. and ſay 707. 1000 :: 38, 42⌊43, ſo then you may take 42⌊43 of the Diameter, and ſet on your ſcale of chords, and then divide each of them into halves, and each half in to 3 parts.

Other-

Otherwiſe thus, The content of this circle according to *Archimedes* is juſt ½ the content of the ſquare of the Diameter. Suppoſe the Diameter 24, the ſquare thereof is 576, the half whereof is 208, the root whereof is 17 *ferè*, then ſay; If 17 in chords require 24 Diameter, what ſhall 40 in chords, or any other even number of fives? *Anſwer*, 56 ½: therefore take 56 ½ of the Diameter, and ſet it in the ſcale of chords, which becauſe it gives 8 times 5, firſt divide it into halves, then into quarters, then into eight.

3. It may alſo be made by this Rule of his, The *area* of the ſquare within the circle is to the content of the circle as 11 to 7, ſo that the circle begin known, the content is thus found: ½ the Diameter multiplied in ½ the Circumference gives the content of the circle, which if you multiply by 7, and divide the product by 33, it gives the content of the ſquare within: whereof take the ſquare-root, and you have the ſide deſired; therefore 19 ⌊ 8.88 :: 20. 88 ⌊ 9, or as Mr. *Wingate* hath it (in *Problem* 33. of his *Appendix* to his *Rule of Proportion*) 225. 1000 :: 20. 88 ⌊ 9. So that take 88 ⌊ 9 from the Circumference and ſet it on this ſcale, and divide it into four fives, and this ſcale may be ſet on the lower half of the beſil'd edge.

4. Having the content of the Circumference, to find the ſide of the ſquare equal. Take the ſquare-root thereof: ſo we found before that the Circumference being 88, the content is 616; whoſe ſquare root is 24 ⌊ $\frac{40}{49}$, that is more then 24 ¼. or more eaſily, becauſe, as *Gunther* hath it, the Circumference is to the ſide of a ſquare equal as 1000 the *Radius* to 282, therefore ſay, 282. 1000 :: 20. 70 ⌊ 9. Therefore take 70 ⌊ 9 of the Circumference, and ſet it in the ſcale of the ſquare equal, it gives 20 of that ſcale; with which diſtance ſet out all the twenties the ſide will bear, dividing each 20 into four fives, and the laſt into five little ones, and numbring them by five as afore: and this ſcale may be ſet in the over part of the third column next the ſquare edge.

Errour in round timber to take a quarter of the circumference for the ſquare.

5. And here I muſt acquaint you with that monſtrous errour in meaſuring round timber which I ſpake of before, which is this, to gird the piece about, and to take the fourth part for the ſquare thereof: as ſuppoſe the piece be 80 inches about, then by this account the ſquare ſhould be but 22 inches: whereas in the laſt ſection we found it to be above 24 $\frac{1}{4}$, whereby the full fifth part of the timber is loſt to the ſeller; which notwithſtanding the moſt of them know to be extream falſe, by reaſon that when they have hewed it, they make a great deal more of it, then they did before it was hewed. But what is their excuſe? Even this they ſay, That will ſcarce pay for the hewing, and it is but ſap and bark. I anſwer, The goodneſs or badneſs of any thing is conſidered in the price; but neither in the meaſure nor the manner of meaſuring. I have ſeen a ſack of fine ſeed, white wheat, ſold for ten ſhillings a buſhel, another of grey wheat at ſeven, ſold the ſame day all to one man: yet he had no more meaſure of the courſe grey, then of the fine wheat. Secondly, In that they ſay, They had need have that for hewing: I ſay, They never hew what they rend to laths, pales, rails, plow-timber, cart-timber, wheel-timber, boles, trenchers, diſhes, ſpoons, and infinite other, which they rend, and ſell ſap and all. Thirdly, When they do hew any timber, they leave it ſo wany, that (in *Cambridge-ſhire* eſpecially) they leave it nearer round then ſquare; and yet allow nothing for the wanes: ſo that in all other things, whether ſold by weight or meaſure, the buyer is to have the draught, though it be but in an ounce of pepper, in this he muſt want of his meaſure, and that no ſmall matter; for they ſeldome hew nigher to ſquare in this Countrey, then that the four wanes are as broad as the four flats, all which are equal to a ſquare piece of the breadth of one of thoſe wanes; & although thoſe wanes be leſs in ſome places then in other, yet will they be of no ſervice ſo deep as the deepeſt wane goes. And what ſenſe or equity is there, that in buying they

ſhould

ſhould deſire ſo much over-meaſure, and yet in ſelling it hewed ſell ſo much ſhort, as in buying? Hath not he that buyeth wane-timber, that the wanes run not ſtreight, as much need, and as much reaſon, to have allowance for the wanes, and to have the knots and bark left on them for hewing, as you to have the fifth part and more, and yet never hew a great deal of it at all? Beſides, you have a trick, when you buy round-timber with the bark on it, be it thick or thin, you will cut a notch round about the piece in the middle of the block, ſometimes deeper then the bark, ſaying, That is but a boin: now you buying by meaſure, what right have you to the bark, which you meaſure not? yet when it is hewed, they that buy it muſt be content with air inſtead of timber. And yet further, I have known a Wheel-wright, that uſed to buy all his timber by the foot of fourteen inches every way to the foot, and to girdle it, and to take the fourth part for the ſquare; thus did he over-reach the ſellers, who thought it to be but a ſeventh part more then ordinary, and that he gave a penny or twopence more in a foot then others gave, they thought themſelves well enough; whereas (poor ſimple fools!) they ſold above two foot for one.

6. If you buy round timber that is ordinarily taper, little or much, then you will be ſure to gird it in the middle, or nearer the little end, whereby you gain no ſmall matter.

Laſtly, How common a thing is it with Wood-mongers, to have one Rule to buy by, & another to ſell by: one a quarter of an inch too long, another as much too ſhort? And great pity it is, that conſidering there are ſo many abuſes in meaſuring land and timber, it is not a whit looked into, whereas in all other things ſold by weight or meaſure the abuſes are puniſhed by the *Clerk of the market.*

Now for correction of this falſe meaſure in round timber, committed by this way of taking the fourth part for the ſquare, if it be a perfect Cilinder, and not taper, you may help your ſelf by this Table, taken out of Mr. *Stirrup's Plain-ſcale*, or *Carpenters new Rule, page* 60, which you may draw into a

ſcale, as you do for ſquare timber or board-meaſure; all but the firſt ſeven inches, which are under-meaſure, and ſet thoſe 7 in four columns, between the two Tables of board and timber under-meaſure.

Squar. Inch.	*Feet.*	*Inch.*	*Cent.*	*Squa. Inch.*	*Inc.*	*Cen.*	*Squa. Inch.*	*Inc.*	*Cen.*
1	113	1	71	11	11	22	21	3	11
2	28	3	42	12	9	42	22	2	80
3	12	6	85	13	8	3	23	2	56
4	7	0	85	14	6	92	24	2	35
5	4	6	30	15	6	3	25	2	17
6	3	1	71	16	5	30	26	2	0
7	2	3	70	17	4	69	27	1	86
8	1	9	23	18	4	19	28	1	75
9	1	4	76	19	3	76	29	1	61
10	1	1	57	20	3	39	30	1	51

The uſe of this Table is thus.

Girt the piece about, and take the fourth part for the ſquare, as if it were the true ſquare, and therewith enter this Table; and it gives the feet, inches, and *Centeſmes* required forward to make a foot forward at that falſe ſquare. So 44 inches circle gives 11 inches for the fourth part, which in the Table gives 11 inches, 22 *Centeſmes*, forward to a foot-ſquare of timber. Or elſe having taken the Circumference with a nealed wier, and there made a twiſt, and meaſured the number of inches about, take off ſo many with your compaſſes, and apply that wideneſs to the ſcale of the ſquare-equal, and you have the ſquare you muſt meaſure it at. And becauſe as I ſaid before, that to hew a log for boards, the beſt way is to hew it eight-ſquare, both for ſaving timber, and to have all the boards ſtreight-edged; ſo neither ſhall the ſawyers be paid for more then they ſaw, nor he that buieth the boards for the block it ſelf, want, or have too much: we will now therefore give you

you one rule whereby to meaſure all equal-ſided timber, ſo that it be not taper, how many ſides ſoever it hath. Firſt, finde the centre of your piece, and meaſure the ſemi-diameter thereof to the middle of one of the equal ſides; then add all the ſides together, multiply half thereof by the ſemi-diameter: ſo have you the content of the baſe, and that multiplied in the length gives the content of the piece. So in the figure the 8 ſides are ten a piece, that is, 80; the half whereof is 40; the ſemi-diameter or perpendicular A B is 12, that multiplyed by 12 makes 480, which is the content of the baſe, that is, one inch ſawed off of the end of the piece. Then if either you multiply 480 by the inches of the length of the piece, and divide the product by 1728, you have the content of the piece. Or elſe you may extract the ſquare-root of 480, which is 22 *ferè*, and then meaſure it, as if it were 22 inches ſquare. And thus may you meaſure all manner of timber, not taper, by meaſuring one inch at the end, as if it were land: then extract the root, and meaſure is as if it were ſo much ſquare.

CHAP. VIII.

Of taper-timber, whether Conical or Pyramidal.

FOr ſuch kinde of timber of either ſort, meaſure it as if it were a whole Cilinder or Priſme, that is, Firſt, finde the *area* of the baſe, and multiply it by the whole length, thus; Let a Priſme be four-ſquare, the ſide 12, the *area* of the baſe is 144, and ſuppoſe the length 100, theſe multiplied make 14400. But by the Corollary of the 7th *Prop.* 12. *lib. Euclid.* every Pyramis is the third part of a Priſme, having the ſame baſe and altitude: therefore divide 14400 by 3, it giveth 4800

4800 the content of the Pyramis. But ſuppoſe it be an imperfect Pyramis, that runs not to a point, but hath his top cut off; you ſhall then continue out the ſides to a perfect Pyramis, by plotting it in paper, or elſe finde how much it wants by the Rule of three. *Example.*

The ſide of the baſe being twelve, the length of the piece fiftie, and the ſide there is ſix, ſo that there is ſix loſt in fiftie; but the whole ſide of the baſe is but twelve, whence take ſix, ſix reſteth. Then ſay 6. 50:: 6. 50. and 50 and 50 make an hundred, as before. Now then for this little Pyramid, the ſide or Diameter of the baſe thereof being ſix, whoſe ſquare is 36, the third part whereof is twelve, that multiplied by 50, gives 600, the content of the leſſer Pyramid. Subtract this perfect Pyramid out of the great perfect Pyramid 4800, reſts 4200, the imperfect Pyramis. And the reaſon, that holds between the Priſme and Pyramis, holdeth alſo between the Cilinder and Cone, *Prop.* 10. 12. *Euclid.* Every Cone is the third part of a Cilinder, having the ſame baſe and altitude.

Of the Cone.

Let us now ſuppoſe a Cone alſo divided in length into 50 and 50, the greater Diameter at the baſe to be twelve, and ſix in the middle. Firſt, to finde the Circumference to 12, the Diameter: 12 multiplied by 22 is 264, that divided by 7 is 37 $\frac{5}{7}$, the Circumference. Then multiply half 37 $\frac{5}{7}$ (that is) 18 $\frac{6}{7}$ by half the Diameter, (that is) ſix, it gives 115 $\frac{5}{7}$, the greater *area*, which multiplied by 100 the length, it gives 11514 $\frac{2}{7}$ the Cilinder, the third part whereof is 3838 $\frac{3}{21}$ the greater Cone, Now for the leſſer, the Diameter is ſix, multiply it by 22, it is 132, that divided by ſeven, is 18 $\frac{6}{7}$ the baſe, which multiply by the length 50 is 942, the third part thereof is 314 $\frac{2}{7}$ the leſſer Cone.

Now take 314 $\frac{2}{7}$ out of 3838 $\frac{3}{21}$, reſteth the imperfect Cone 3520, which is almoſt twelve times as big as the leſſer. Or, if you rather deſire 12 and 6, the baſes of the Pyramis, to be the ſides of the ſquare within the circle, as there they are, and then to ſee their dimenſions: then firſt, if twelve be a ſide

of

of a ſquare within the circle, ſince the content, or ſquare thereof, is but half the content of the ſquare of the Diameter: therefore double the ſquare thereof, and out of the double extract the ſquare root, and you have the Diameter: ſo 12 ſquared is 144, that doubled is 288; whoſe ſquare-root is 17 *ferè*, the Diameter.

Now to finde the Circumference, multiply 17 the Diameter by 22, *facit* 374. that divide by ſeven, it quoteth 53 $\frac{1}{7}$ the Circumference: then multiply half the Circumference 26 $\frac{1}{7}$ by half the Diameter 8 $\frac{1}{2}$, it gives the *area* of this baſe 227 $\frac{1}{14}$, which multiplied by 100, the length, gives 22707 $\frac{1}{7}$ the Cilinder, which divided by 3 gives the great Cone 75695 $\frac{1}{2}$. Likewiſe for the leſſer ſquare within, which is ſix, the ſquare is 36, that doubled is 72, the ſquare-root whereof is 8 $\frac{1}{2}$ *ferè*, the Diameter. Multiply 8 $\frac{1}{2}$ by 22, it gives 187; which divided by 7 gives 26 $\frac{1}{7}$ the Circumference, then multiply half 26 $\frac{1}{7}$ (that is) 13 $\frac{1}{14}$, by half 8 & an half (that is) 4 $\frac{1}{2}$, and you have 56 $\frac{12}{98}$ or ⌊72 *ferè*, the content of that *area*; which multiply by 50 the length gives 2835: the third part thereof is 945, the leſſer Cone. Take this leſſer 945 out of the greater 7569, reſteth 6624, the imperfect Cone: So that the imperfect Cone is more then ſeven times as big as the little one.

The diſcovery of ſeverall errours in meaſuring the Pyramid and Cone: and firſt of the Pyramid.

Some hold that to be true, To add the *areaes* at both ends together, and multiply the 1 half thereof by the length of the piece, as in our example the *area* of the great end is 144, and the little end nothing therefore half 144 (*i.e.*) 72 multiplyed by 100 is 7200, but it ſhould be but 4800: it is too much by 2400.

A ſecond errour is to take the *area* at the third part from the great end, as in this figure, at C and C, but there the ſquare or ſide is 8, and the ſquare number or *area* thereof is 64, which multiplied by 100 is 6400, too much by 1600.

A third errour is to take the ſquare in the midſt of the piece,

as at B and B, where the ſide is 6, the *area* 36: that multiplied by 100 the length gives 3600, which is too little. for take 3600 out of 4800, the difference is 1200; a juſt quartern loſt of the timber to the ſeller; ſo that it falleth near the middle between B and C, where it is 7 inches, for that gives 5900, yet there it is too much by an hundred.

Secondly in the Cone.

The common practiſe is to gird it in the middle, and to take the fourth part for the ſquare. In meaſuring the cilinder, there was more then the fiſt part loſt to the ſeller: but here that it is taper alſo, is a more intolerable loſs. For if in the ſquare Pyramid was loſt a full quartern onely by reaſon of tapering: what will here be loſt where two ſuch errours combine in one to wrong a man? The Circumference in the midſt of the piece is 26 $\frac{1}{7}$, the fourth part thereof is 6 $\frac{1}{4}$, which ſquared is 45 $\frac{1}{2}$ and that multiplied by 100 makes 4556 $\frac{1}{4}$, which taken out of 7569, there is loſt to the ſeller 3013, which is almoſt one half thereof. Yet this goeth ſo for currant in all places, that he that contradicts it is ſcorned as a fool, and accounted as a knave.

CHAP.

CHAP. IX.

Of the making of four other lines on the flat-ſides, whereof three are Mr. Gunthers *lines, of numbers, ſines, and tangents; and inſtead of the Meridian line, which is onely uſefull for Navigation, whereof Carpenters make little or no uſe, we have added a ſextant of chords.*

ALthough *Mr. Wingate* (in his book called *The Rule of Proportion*,) hath ſet down the making of them: yet for that he hath done them after another manner then here is ſhown, neither will an ordinary Rule bear all thoſe lines, we will therefore content our ſelves with *Mr. Gunther's*, & the line of chords onely. You ſhall divide the reſt of the Rule beſide the columns of feet & inch-meaſure before ſpoken of, into four other great columns, and divide each of them into two equal, and one of them into two alſo; ſo the great ſhall be for figures, the other 2 for ſtrokes. Theſe two of Mr. *Gunthers* you may ſet in the three middle columns, and the line of chords on the other outſide.

Firſt, for making the line of numbers.

I told you before that I would have you ſtrike a ſtroke round about croſs the Rule, I would alſo have another at each end of the Rule ſo cloſe as poſſibly you can, onely to ſet one point of the compaſſes on. Then firſt ſet out your great diviſion in each foot; *viz.* the thouſands, if your number conſiſt of four figures, or howſoever they are to be the left hand figures of any number, as 3 in 3 32. 346. 3654. 37046, &c. and muſt be marked with the 9 digits in either foot, and the firſt laſt and middle-moſt with one, ſo that you may underſtand as many ciphers with it as ſhall be requiſite, ſo that it may ſignifie 1. 10. 100. 1000. and then if one ſignifie 10 the next two will naturally ſignifie 20, but not always. Now to take and ſet the number 2 in his right place, take a Table of Logarithmes of abſolute numbers, and look either the Logarithme of 2. 20. or 200. and

take the three next figures to the Characteriſtick, which are 301: then with your compaſſes take 301. *viz.* three inches, no tenth part of an inch, and $\frac{1}{10}$ of a tenth part or *Centeſmes* of an inch, and ſet one foot in the nether-moſt croſs ſtroke, where you ſet the firſt one, and turn the other upward in the ſame column, and there ſet your 2 likewiſe with the ſame numbers, ſet one foot in the middle croſs ſtroke where you ſet the middle one, and turn the other upward toward the uppermoſt one, and there ſet your 2 alſo: likewiſe, do with 3 whoſe Logarithme is 477 (*id eſt*) 4 inches, 7 tenths; 7 *Centeſmes*: alſo with 4. And theſe figures for the making of this line we will call hundreds, the next ſubdiviſion tens, and the leaſt *Centeſmes*. But now becauſe we will ſuppoſe your compaſſes will not well reach beyond the figure 4, whoſe Logarithme is 602, that is above 6 of thoſe inches: therefore firſt, let us ſet on the tens ſo far on both feet, and then the reſt of each foot afterward. Next ſet out each fifth tenth ſo far: becauſe you muſt mark them with longer ſtrokes, then each ſingle ten: ſo then you muſt not account the next of thoſe fifths to 1 as 5. (for then you will account the one for nothing) but you muſt account it for 15. or 150. and ſo take the Logarithme thereof, which is 176. Likewiſe 25, or 250, is 398, which you muſt take with your compaſſes, and ſet in their places in in both feet, and in like ſort ſhall you do with all your ſingle tens; accounting that next 1 not for 1, nor 2, but for 11. Or inſtead of taking them off with your compaſſes, ſtrike out all the firſt foot with a fine ſmall ſtriking ſquire of braſs, laying it upon the Log. in the line of foot-meaſure, and then ſet out the other foot with your compaſſes by this.

Now for the reſt of each foot, look out the Logar. of your numbers, and take the diſtance between it and the middle croſs-ſtroke, and with that wideneſs ſet one foot in the upper 1, and where the other falls, there is the place of that number. *Example.* I would ſet out 70, the Log. is 845; I take the diſtance between it and the middle-ſtroke of the Rule, or the Arithmetical complement of it, 154, and ſet it both from the upper

ſtroke

ſtroke and middle-ſtroke downward, and you ſet out ſeventy. But your over-foot may bear unites to 20, and from thence to 40, divide each tenth into five, and from thence to the end into two.

To make the line of ſines.

Firſt, you muſt know that neither the line of ſines, nor tangents, enter the Rule till 35 minutes: where you ſee the two next figures to the characteriſtick 8, are both ciphers; there alſo the characteriſtick changeth from 7 to 8: for your characteriſtick ſhews what foot you are in: therefore ſince we reckon the minutes onely by tens, our firſt number or diviſion upon the Rule will be at 40 minutes of the firſt foot, ſhewn by the characteriſtick 8: for 9 is the laſt, and therefore belongs to the laſt foot; ſo that whereas you ſee that the Log. of one minute hath 6 the characteriſtick, & 463 the three next figures: therefore one minute would be above a foot and half before the entrance on the Rule, and likewiſe would the firſt minute of the tangents be. Now the Logar. of 40 minutes hath beſide the characteriſtick 8 the three firſt figures 066 *feré:* therefore take off 0 inch, 6 tenths, and 6 *centeſmes*, or 5 *centeſmes*, and 7 *milleſmes*, if you can ghueſs ſo near, and ſet them from the nethermoſt croſs-ſtroke at the beginning of the line of ſines forward. And thus do for all under two degrees, be it ſine or tangent: but from thence to ſine 5 degr. 45 min. or tangent 5 degr. 43 min. (As ſuppoſe the ſine of 4 degr. whoſe Logar. beſide the characteriſtick is 843:) you ſhall take the diſtance between 8 inches, 4 tenths, 3 *cent.* and ten inches, and apply that diſtance from the middle-ſtroke down-ward: and ſo of the reſt of the quarter. But for all both ſines and tangents in this firſt foot: you may by their Logarithmes ſtrike them with a ſquare, as you did the line of numbers.

Now for the upper-part ſhewed by the characteriſtick for all ſines and tangents to 20 degr. as ſuppoſe the tangent of 20 degr. the Logarithmes of 20 degr. tangent is 56: ſet it from the middle-ſtroke forward, but from thence to the ſine of 90, and tangent of 45 degr. as the ſine of 40, whoſe Logar. is

808; take the diſtance between it and the middle-croſs-line, and apply it in the line of ſines from the upper croſs-ſtroke down-ward: then number all the whole degrees to ten, with 1, 2, 3, and after that in the ſines with 20, 30, 40, &c. to 90, and the tangents with 10, 20, to 45, and back with 50, 60, to 80 degrees.

Laſtly, for making the ſextant of chords.

Set a pair of beam-compaſſes, with a beam of willow, deal, or ſallow, near half an inch thick, and $\frac{3}{4}$ broad; make a little nut of good tough wood, with a mortes in it, that the beam may ſlide in it to and fro, indifferently ſtiff, and in all places alike, with a ſhort prick, or little piece of an aule-blade in one end, and another longer in one edge of the beam hard by the end, ſo long from the beam as the other point is. If it goeth not ſtiff enough to ſtand and tran with at any place, make the mortes a little the deeper one way to put in a wedge, or elſe help your ſelf with a ſcrew-pin, then go to ſome ſmooth loft boards, opening your compaſſes to 23 $\frac{1}{2}$ inches, and with that wideneſs tran an arch, that may be two foot long at the leaſt, and with each foot of the compaſſes make a prick in the ſaid arch, and ſet it likewiſe upon the Rule; then divide that ſpace in the arch into two equal parts, which will be 30 degr. a piece, and each of them into three apiece, which will be 10 degr. apiece, and each of them into two, which will be five apiece, and each of them into five ſimple ones. Then take them off from the floor, and ſet them on the Rule, one after another, and number them with 10, 20, 30, 40, 50, 60, and this will be wonderfull beneficial in Dialling, and alſo in many other things, as to divide a circle into any number of equal parts, or to make an angle of any number of degrees, or to finde the quantity of any angle, and ſo by the line of foot-meaſure you may alſo divide a ſtreight line into as many parts as you will.

Now as I have ſhewed the uſe of all the lines on the other ſide of the Rule, and alſo of both the out-ſide lines on this ſide; ſo for the other three I muſt content my ſelf to ſhew you

you the uſe in general: for if I ſhould deſcend to particulars, all the paper in *Cambridge* would be too little to hold them. Firſt therefore, you ſee already, that as by the line of foot-meaſure, and Table of Logarithms theſe lines are made; ſo may you by theſe lines finde the Logarithme of any abſolute number, tangent or ſine, as if it were by the Table of Logarithms.

Secondly, By theſe two lines of numbers and foot-meaſure may be reſolved all queſtions whatſoever, that common Arithmetick can reſolve. And more; for hereby may be reſolved all queſtions of Intereſt, Purchaſes, Annuities, &c.

Thirdly, By theſe three lines of numbers, ſines, and tangents is reſolved the whole doctrine of Triangles, and whatſoever may be performed by them, either in Meaſuring, Dialling, Geography, Geometry, Arithmetick, Navigation, Coſmography, Aſtronomy, &c.

But, becauſe (gentle Reader) I would have thee learn now to go alone; I will commit theſe to thine own conſideration, knowing that that chicken that will peck up never a corn, but what the hen puts in the mouth, will never be a fat chicken.

Now if the Rule of three is accounted of all men worthy for its excellency of the name of the *Golden-Rule* (which is but the leaſt part of the uſe of one of the lines of this Ruler) then juſtly may this Ruler be called the *Golden-Ruler*.

FINIS.

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